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SIMULATORS FOR MARINER TRAINING AND LICENSING

PHASE 1: THE ROLE OF SIMULATORS IN THE MARINER TRAINING AND LICENSING PROCESS

VOLUME II

JULY 1980

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16. Abstracts

Simulation technology has progressed to the point that it may present a cost effective means for enhancement of the mariner training and licensing process. The use of simulation in the deck officer training and licensing process is under investigation. This first phase has developed a large information base pertaining to deck officer behavior and training technology; has developed a methodology to evaluate alternative training system characteristics; and has identified a broad set of relevant issues that require further empirical research. Later phases are planned to investigate these issues.

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SIMULATORS FOR MARINER TRAINING AND LICENCING PHASE 1: ROLE OF SIMULATORS IN THE MARINER TRAINING AND LICENSING PROCESS

VOLUME II

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APPENDIX A

BEHAVIORAL DATA BASE

A.1 INTRODUCTION

This discussion traces the formulation of a behavioral data base developed as a foundation for establishing the specific functional objectives (SFOs) of a qualified master. The resultant set of SFOs (i.e., training objectives) presented in Exhibit A-8 represents the design goals for the training system.

A.2 METHODOLOGY

The approach followed in developing the specific functional objectives was adapted from one developed and exclusively used by the United States Air Force and Navy. It is generally known as the systems approach to training (e.g., Chenzoff and Folley, 1965; Jeantheau, 1970). In accordance with this approach the following subtasks were performed sequentially to yield the set of SFOs:

a. Task Analysis. Deck officer task analysis data previously generated from several independent studies was utilized, thus substantially decreasing the cost and time required to perform this subtask.

b. Identification of Skill and Knowledge Requirements. Skills and knowledge that the master must possess to perform those tasks defined in the task analysis were identified. Originally, a combined set of skill and knowledge requirements was formulated for a master of an 80,000 dwt vessel upgrading to a master with pilot endorsement of a 170,000 dwt vessel. As a result of meetings with the Working Group, it was decided to address only the skill and knowledge requirements expected of a master operating any vessel.

c. Identification of Input Characteristics. Based on the skill and knowledge requirements identified, on a review of USCG texts (e.g., Specimen Examinations for Merchant Marine Deck Officers) and on discussions with licensed mariners, the input characteristics of a master for a 30,000 dwt class vessel were identified. Input characteristics are the relevant skills and knowledge a master is likely to possess prior to entering simulator-based training.

d. Definition of Hypothetical Port. The characteristics of a hypothetical port, Port XYZ, were defined by listing conditions that could exist in any port. This subtask was performed because of the original intent of the project to deal with the training of a master with pilot endorsement. See Exhibit A-3 for details.

e. Development of SFOs. Based on the results of the previous subtasks, a set of specific functional objectives, representing the design goals for the training system, was developed.

Each of the above subtasks is described in more detail in section A.3 below.

A.3 RESULTS AND ANALYSIS

A.3.1 Task Analysis

Of the several independent studies from which task analysis data was derived, the following four were reviewed as primary sources:

- Operations Research, Inc. (ORI)
- General Dynamics, Electric Boat Division (EB)
- Eclectech Associates, Inc.
- University of Washington

The first three studies cover both open sea and restricted waters tasks, while the University of Washington study deals exclusively with restricted waters tasks. The emphasis of each study is briefly summarized below.

In 1976 Operations Research, Inc. conducted a task analysis for the United States Coast Guard. ORI's analysis addressed both restricted waters and open sea tasks which deal with visual activities, evaluation of data input, ship control, orders issued, navigation, and communication. Their analysis yielded a set of tanker tasks (Goals I-V) and a set of towboat tasks (Goals I-III). Unlike the other studies, the ORI study categorized personnel as "bridge personnel" instead of listing each person's title or function.

For the present task analysis, the ORI towboat tasks were excluded from review as were tanker tasks not specifically related to shiphandling (such as tasks involving voyage preparations, crew training, and supervision). Areas included were tanker tasks related to:

a. Goal II: Berth/unberth ship expeditiously without damaging wharf, pier, mooring buoy, own ship, or other vessels (17 tasks).

b. Goal III: Navigate through (maneuver in) restricted waters as required in order to reach destination safely and expeditiously (44 tasks).

c. Goal IV: Navigate through (maneuver in) nonrestricted waterways in order to avoid rammings and groundings (44 tasks).

The Electric Boat Division of General Dynamics conducted a task analysis in the late 1960's for the Maritime Administration. Their study substantially defines the functions involved in maneuvering and piloting a vessel. It emphasizes tasks which address orders issued, ship control, collision avoidance, navigation, and log keeping. It was reviewed in its entirety. Task areas include:

a. Restricted waters with a pilot on board (32 tasks).

b. Restricted waters without a pilot on board (19 tasks).

c. Navigation of the open sea for limited and unlimited visibility (25 tasks for limited visibility; 24 tasks for unlimited visibility).

d. Avoidance of a vessel (20 tasks).

e. Avoidance of an object (11 tasks).

f. Docking (26 tasks).

A separate study recently conducted by Eclectech Associates, Inc. compiled a more extensive, in-depth data base concerning at-sea behavior of masters and pilots in United States waters and those of the English Channel. This computerized data base, collected entirely at sea, consists of an accurate task analysis correlated with external events such as locations, harbors, and waterways, and/or other shipping contacts. A total of 70 tanker and container tasks for both open sea and restricted water areas are covered, addressing visual activities, navigation, collision avoidance, communication, and ship control. In addition to the at-sea data base, results from an experiment conducted on the CAORF simulator (Restricted Waterways Experiment) provided data on pilot tasks.

The University of Washington conducted a study in 1975 on pilot behavior in restricted waters (Puget Sound). The resulting data provide an extensive overview of the key behaviors of pilots in restricted waters. This study, also reviewed in its entirety, covered both passenger and merchant vessel tasks relating to:

- Position
- Visual activity
- Auditory functions
- Motor functions
- Radio communication
- Command control
- Critical incidents

For a tabular synopsis of emphasis across the four studies, see TABLE A-1. A comparison shows that the emphasis of each study varies. The analyses are thus complementary rather than duplicative.

Also reviewed for acquisition of supplemental data were:

- Pilot Decision-Making While Maneuvering in Confined Waters (Carpenter and Huffner, 1977)
- Pilotage in Confined Waterways of the United States: A Preliminary Study of Pilot Decision Making (Huffner, 1976)
- Shiphandling and Shiphandling Training, TAEG Report No. 41 (Cordell and Nutter, 1976)

To integrate the data collected during this task analysis and eliminate any redundancy, four categories believed to be representative of all shiphandling situations were identified: (a) open sea, (b) restricted waters, (c) mooring, and (d) casualty. A composite set of tasks from the task analysis survey was segregated into the appropriate categories. (See Exhibit A-1.)

From this process, five tables were developed corresponding to the above four situations, with the fifth table resulting from the separation of the casualty data into open sea and restricted waters segments. For each task the tables indicate: (a) the task source; (b) the information available regarding each task, such as task frequency, time duration, criticality, percentage of total workload performance measures, performance standards, skills and knowledge, operational sequence diagram, and functional flow; (c) the type of ship on which the task was identified; and (d) the person/position for which the task was identified (See Exhibit A-2.)

To ensure completeness, the comprehensive task tables were reviewed and any additional tasks that could be identified were added to the Eclectech Associates segment of this task analysis.

TABLE A-1. SYNOPSIS OF EMPHASIS, TASK ANALYSIS STUDIES

	OPERATIONS RESEARCH, INCORPORATED	ELECTRIC BOAT	ECLECTECH ASSOCIATES	UNIVERSITY OF WASHINGTON
Operating area	Open sea Restricted waters	Open sea Restricted waters	Open sea Restricted waters	Restricted waters
Personnel involved	Bridge personnel	Master Mate Pilot Helmsman Bow lookout	Master Mate Pilot Helmsman Bow lookout	Master Mate Pilot Helmsman
Task performance Open sea	Bridge personnel	Master Mate Helmsman Bow lookout	Mate	
Restricted waters	Bridge personnel	Master Mate Pilot	Master Mate Pilot Bow lookout	
Task emphasis Open sea	Visual tasks Orders issued Navigation Communication Ship control Evaluation of data input	Orders issued Navigation Ship control Collision avoidance	Visual tasks Navigation Communication Collision avoidance	

TABLE A-1. SYNOPSIS OF EMPHASIS, TASK ANALYSIS STUDIES (CONT'd)

	OPERATIONS RESEARCH, INCORPORATED	ELECTRIC BOAT	ECLECTECH ASSOCIATES	UNIVERSITY OF WASHINGTON
Restricted waters	Visual tasks Ship control Evaluation of data input	Orders issued Navigation Ship control Log keeping	Visual tasks Navigation Communication Ship control Collision avoidance	Visual tasks Communication Collision avoidance Critical incidents
OTHER			Note 1	Note 2

NOTES:

1. Very specific tasks are identified in the areas of navigation and collision avoidance.
2. General task categories: Position, posture, outside visual, inside visual, auditory, motor, radio communication, command control, and critical incident.

A.3.2 Identification of Skill and Knowledge Requirements

Training analysts and maritime consultants analyzed the comprehensive task tables to determine the skills and knowledge that the master must possess to perform each task. A skill/knowledge listing is required based on the fact that skills, not tasks, are trained. Skills and knowledge may be common to several tasks and applied to various situations. If a task is trained as a single entity, the training might not transfer when given a relatively similar, yet different, situation.

The resultant set of skill (Exhibit A-5) and knowledge (Exhibit A-6) items for restricted waters were organized into seven categories: navigation, communication, environmental elements, radar/CAS, maneuvering, docking/mooring/anchoring, and emergencies. This method was considered the most descriptive way of representing the derived information. The various types of skills addressed by each category are:

a. Navigation. Use of electronic (i.e., Loran and Decca) and visual indications of position. Action taken in response to course, speed, and turn rate indicators.

b. Communication. Use of both internal (sound-powered phone) and external (VHF) means of communication. Use of whistle signals, signal flags, and navigation lights.

c. Environmental elements. Consideration of effect of set and drift. Decisions to deviate from course based on existing or future weather conditions.

d. Radar/CAS. Operation of equipment for hazard and aid detection and collision avoidance.

e. Maneuvering. Transiting through light turns in the channel, avoiding obstructions; approaching/departing a pilot station; maneuvering in high winds, strong currents, and varying degrees of visibility; navigating in ice, performing Kempf and spiral maneuvers and Williamson turns.

f. Docking/Mooring/Anchoring. Development of approach plan and the use of tugs for assistance.

g. Emergency. Action in maneuvering the vessel in the event of equipment, rudder, propulsion, and electrical failures, fire on board, and man overboard emergencies.

An overall analysis of skills indicated that shiphandling skills do not appear to differ among vessels. Rather, the level of skill differed. The skill levels were further found to differ due to the underlying abilities of the mariner (e.g., his ability to perceive motion characteristics of distinctively different vessels). Therefore, the training emphasis should be placed on the required level of skill associated with particular abilities.

A.3.3 Identification of Input Characteristics

Input characteristics refer to the relevant skills and knowledge likely to be possessed by the master prior to entering simulator-based training. (See Exhibit A-7.) The following categories represent the nine areas covered by the input characteristics:

a. Navigation
b. Electronic indications of position
c. Communication
d. Ship characteristics

e. Anchoring/docking
f. Ship control/non-ship control emergencies
g. Man overboard
h. Fire onboard
i. Collision and/or flooding

These categories deal only with those skills that apply to the conning of a vessel in the 30,000 dwt class. If these same categories of skills dealt with conning a vessel in the 170,000 dwt class, the skills would no longer be considered input characteristics. Therefore, it would be necessary to determine the actual set of input skills required to operate a vessel of 170,000 dwt.

A.3.4 Definition of Hypothetical Port

The development of a hypothetical port, Port XYZ, involved construction of a comprehensive list of the services, turning basins, piloting aids, hazards, channel characteristics, environmental factors, and moorings that might be found when conning into any port. These port characteristics provide the basic variables which can be combined to form the various situations which will be used when developing the specific functional objectives.

A.3.5 Development of Specific Functional Objectives

The set of specific functional objectives is the major product of the behavioral data base. The SFOs were derived from the sequentially completed subtasks described above and from a review of existing casualty data. (See Exhibit A-4.) The SFOs (see Exhibit A-8) represent highly detailed shiphandling objectives to be achieved by masters of a vessel with a high block, low power coefficient (e.g., a 170,000 dwt vessel) as a result of the training program. The larger ships afloat have increased in size nearly a hundredfold over the past 50 years from about 6,000 to 500,000 dwt (Special Committee on Large Ships, Final Report, September, 1976). As a function of hull-related factors, the design of these larger vessels causes a variety of unusual handling characteristics, some of which are significantly different from those of smaller vessels. Each SFO accordingly comprises two segments: (a) the behavior (i.e., the specific skill and/or knowledge to be attained by the master as a result of training and/or experience), and (b) the conditions that describe the circumstances under which the behavior should be performed.

A.3.5.1 Behaviorial Segment of SFOs. The behavioral segment of the SFOs were grouped into five categories. These categories with their associated topics represent those skill areas that should be trained for a master to develop a complete understanding of the vessel's handling characteristics to ensure its safe operation. They are:

a. Fundamental shiphandling

   1. Ship environmental effects

      (a) Wind
      (b) Current
      (c) Tide
      (d) Sea state

   2. Ship characteristics

      (a) Turning circle

(b) Response time - rudder/heading change rate
(c) RPM
(d) Effect of draft, freeboard, block coefficient
(e) Stopping a vessel

3. Hydrodynamic effects

(a) Suction
(b) Bank

4. Maneuvering techniques

(a) Zig-zag
(b) Spiral
(c) Williamson
(d) Kick effect
(e) Turn

5. Rules-of-the-Road

(a) Stand-on
(b) Give-way
(c) Whistle signals

b. Integrated shiphandling

1. Port entry

(a) Navigation
(b) Communication
(c) Pick up/drop off pilot
(d) Traffic separation schemes

2. Restricted waterway/channel navigation and shiphandling

(a) Channel bends with bow thruster
(b) Bridge structure
(c) Channel configuration
(d) Blind turns
(e) Avoid obstacles, hazards
(f) Ice navigation
(g) Use navigation aids - masked, missing
(h) Tug assistance

3. Approach a single point mooring

(a) Approach bearings and speed
(b) Maneuver

4. Approach a dock

(a) Approach bearings and speed
(b) Maneuver with tug assistance

5. Approach an anchorage

(a) Select courses and turning bearing
(b) Maneuver to anchorage
(c) Anchor and fix position

c. Emergencies

1. Anchor or ground the vessel

2. Rudder failure
3. Power failure
4. Electrical failure
5. Communication failure
6. Ship control errors by personnel
7. Tug assistance when casualty occurs
8. Equipment failure

d. Team coordination/communication

1. Parallel and serial functions
2. Transmittal of information

e. Bridge procedures

1. Organize port entry/exit passage plans with alternatives for the development of the unexpected

2. Execute these plans

A.3.5.2 Condition Segment of SFOs. Fourteen conditions, which are representative of all possible situations which could exist while maneuvering a vessel in restricted waters were established with modifications from the Working Group. Every SFO should be achieved under all these conditions. The various definitions and limitations assigned to the conditions are discussed below as necessary.

Varying levels of visibility were grouped into four sections: (a) visibility limited to own ship's bow, (b) 0 to 1 mile, (c) 2 to 5 miles, and (d) unlimited. These divisions were derived by a study of the Meterological Optical Range of the International Visibility Code. Visibility limited to own ship's bow is equivalent to the existence of a thick fog; 0 to 1 mile, to the presence of a thin fog; 2 to 5 miles, to a light haze; and unlimited, to clear visibility.

Specific geographic constraints of varying complexity dealt with channel width and depth. A minimum channel width of 700 feet was defined based on a minimum acceptable width of five times the beam of the largest ship. For example, the beam of a tanker with a displacement of 225,000 tons is 155 feet; the corresponding minimum acceptable channel width is 700 feet. A minimum acceptable channel depth was defined as at least 2 feet below the keel of the vessel.

Limitations were set on the varying environmental factors of wind, current, and tides. The upper limit of wind speed was established at 50 knots based on a review of the Beaufort Scale. (Beaufort Force 10 is equal to 52 knots.) Tide heights of up to 20 feet were established based on data indicating various tide heights for ports around the world. For example, a tide height of 18 feet was reported in Juneau, Alaska.

An upper limit of 20 knots was established for own ship speed.

Varying sea states were grouped as: (a) 0 to 3, denoting a calm to slight sea; (b) 4 to 5, specifying moderate to rough seas; and (c) over 5, indicating very rough to phenomenal seas.

The remaining nine conditions are self-explanatory (e.g., loading condition: (a) fully loaded, (b) light, (c) ballasted).

Further investigation of these conditions is required to determine if all the conditions are needed for training. These 14 conditions may be found to be a subset of a later determined set.

A.3.5.3 Assignment of SFOs to General Training Method. Each SFO was analyzed to determine how it could best be accomplished with consideration for cost, safety, simulator limitations, and training control. See TABLE A-2 for specific results.

Generally, analysis of TABLE A-2 shows that:

- The majority of the SFOs can best be accomplished through simulation based on reasons of safety and training control.
- Objectives dealing with sea states and maneuvering through ice are best accomplished through on-the-job training because of state-of-the-art simulator limitations.

The objective of determining approach bearings and the point at which to reduce speed or stop engines when approaching the dock with tug assistance can best be accomplished by either simulator or on-the-job training.

The majority of SFOs can best be accomplished through simulation because:

a. The environment (e.g., weather, current, visibility) can be controlled and modified at will to suit any condition desired for different needs of training.

b. Ship traffic and movements can be varied at will without facing the problems of actual grounding or collision.

c. Characteristics of vessels, harbors, and navigational aids can easily be incorporated in a simulator to represent typical or extreme examples.

d. Variations of the condition of a vessel such as loading, speed, rudder response, and power available can be programmed and used in any portion of a training exercise.

e. Emergencies or unusual equipment failures can be introduced at any time.

A.3.5.4 Simulator Versus Classroom and On-the-Job Training. The use of simulators for training of masters has been emphasized throughout this section. The total knowledge or training required for a competent master is much broader, however, than that which can be provided by simulator training. Some areas of knowledge that would be better acquired from classroom instruction or an on-the-job training program include:

a. Navigation and related skills requiring lengthy calculations or supplementary tables such as:

   - Celestial and great circle navigation
   - Star identification
   - Compass compensation
   - Chart corrections - aids to navigation
   - Fuel conversation
   - Weather forecasting - ship's routing

b. Cargo storage and handling

TABLE A-2. ASSIGNMENT OF SFOs TO GENERAL TRAINING METHOD

CATEGORY	ON-THE-JOB TRAINING ONLY	ON-THE-JOB TRAINING BEST	SIMULATOR OR ON-THE-JOB TRAINING	SIMULATOR BEST	SIMULATOR ONLY
Fundamental Shiphandling		A3(SL)		B1-5(TC)(C) D1,2,3,5(TC)(C) E1-3(TC)(S)	A1, 2, 4(TC)(S) B4c(TC) C1-2(TC)(S) D4(TC)(S)
Integrated Shiphandling		B10(SL)	D1	A1-14(TC) B1-9(TC)(S) B11(TC)(S) B14a(TC)(S) B15-19(TC)(C) C1-2(TC)(S) D2(C) E1,2(TC)(S) E3(S)	B12-13(TC)(S)(C) B14b(TC)(S)(C)
Emergencies				1(TC)	2-11(TC)(S)
Team Coordination/ Communication				1(TC) 2(TC)	
Bridge Procedures				1 2	

TC = Training Control
SL = Simulator Limitations
C = Cost
S = Safety

c. Stability and ship construction

d. Areas of application, exceptions, authority, and penalties as applied in the Rules of the Road

e. Rules and regulations for merchant vessels

f. Laws governing marine inspection

g. Use and maintenance of lifesaving equipment

h. Ship sanitation - medical, health

i. Ship's business/management

    1. Interface with shore personnel
    2. Port authorities

        (a) Agriculture
        (b) Immigration
        (c) Customs
        (d) Quarantine

    3. Company correspondence, requisitions
    4. Communications/radio - weather reports
    5. Dispensing of money (i.e., payrolls, vouchers, records)
    6. Personnel problems with unions, individuals
    7. Checking of routine reports

        (a) Log books
        (b) Weather
        (c) Deck and engine abstracts
        (d) Inventories

    8. Ordering of tugs and pilots
    9. Distribution of information to relevant personnel

j. Pollution control

Formal on-the-job training under the direction of senior officers is not an established practice within current union guidelines or company policies. Informally some masters have initiated unstructured on-the-job study programs, but because of the rapid turnover of personnel from the union and ship/leave scheduling, an ongoing structured course of study would require extensive company/union planning and cooperation.

Utilizing an actual vessel primarily for training is obviously too expensive, time-consuming, and disruptive to be a viable training mechanism except in isolated circumstances. Approaches that may prove useful for on-the-job training include:

a. Use of video tapes especially for delineating specific, current problems associated with cargo or safety and for presenting information on new trends and equipments.

b. In-company qualification programs similar to programs currently used to qualify men in submarines. The goal of these programs would be to ensure that masters and mates are expanding their knowledge and skills concurrently with technological expansion and change in the marine industry.

   Despite the advantages to on-the-job training, its drawbacks (such as the added burden on the masters, extreme time inefficiency, and a lack of control over the environment) have made the use of simulation a much more attractive alternative.

A.4 CONCLUSIONS AND RECOMMENDATIONS

a. Deck officer shiphandling skills appear to differ little among vessels.

b. Fundamental abilities were identified which appear to be common across skills. The training program should place emphasis on the appropriate abilities underlying the SFOs.

c. Five categories of SFOs were designated as pertinent to shiphandling training:

1. Fundamental shiphandling
2. Integrated shiphandling
3. Emergencies
4. Team coordination/communication
5. Bridge procedures

d. Based on training control, safety, and cost, the vast majority of SFOs related to shiphandling may be more effectively accomplished through simulation as opposed to on-the-job training.

A.5 RESEARCH ISSUES

a. Develop SFOs for other areas or specific categories of training (e.g., refresher, upgrading, transition) using the same methodology as described herein.

b. Develop docking and mooring tasks and skills for the simulator as the simulation state of the art increases.

c. Further develop open sea tasks and skills as part of the deck officer information base.

d. Further investigate on-the-job training; identify SFOs most appropriately achieved in the OJT context.

e. Develop other task and SFO areas relevant to deck officer training, engineering officer training, etc.

f. Determine the range of conditions actually needed in training.

g. Determine actual (versus assumed) input characteristics.

h. Explicitly define and investigate the abilities underlying the skills, and the ship/situation factors that affect them.

i. Explore human factors issues such as perception of motion.

j. Introduce casualty data in reference to human error and specific functional objectives.

k. Investigate the validity of SFOs.

l. Investigate the completeness of the set of SFOs.

EXHIBIT A-1

TASK LISTING

OPEN SEA

I. VISUAL TASKS

a. Look out with binoculars in wheelhouse.
b. Visually scan surrounding waters.
c. Move to bridge wing.
d. Wait for navigational aids to pass abeam (navigation).
e. Obtain visual ranges and bearings to aids.

II. ORDERS ISSUED

a. Order helmsman to change course.
b. Convey navigation orders to other personnel.

III. TASKS INVOLVING THE USE OF NAVIGATIONAL HARDWARE

a. Take Loran data, two and three stations.
b. Plot Loran data, two and three stations.
c. Compare gyro and magnetic compasses.
d. Operate radar for hazard and aid detection.
e. Obtain electronic indications of position.
f. Take fathometer reading.
g. Use radar to find range to navigational aid.
h. Take sun azimuth deviation.
i. Perform miscellaneous navigational calculations in chart room.
j. Acquire alphanumeric contact or navigational data from CAS.
k. Plot navigation fix in chart room.
l. Plot satellite navigational data on chart.
m. Check position plotted by mate.
n. Study intended track.
o. Work in chart room.

IV. COLLISION AVOIDANCE TASKS

a. Keep lookout with Radar No. 1.
b. Reflection plot one or two points on radar.
c. Acquire one or two contacts on CAS.
d. Delete one contact on CAS.
e. Adjust and tune radar or CAS.
f. Erase reflection plots.

g. Look out with CAS.
h. Silence alarm.
i. Determine bearing and range on radar.
j. Decide avoidance techniques.
k. Monitor other or own ship's movements.
l. Report contacts (bow lookout).
m. Report contacts (quarter master).
n. Report contacts (captain).

V. COMMUNICATION TASKS
  a. Use sound powered phone.
  b. Use multichannel VHF FM.
  c. Call to own ship VHF FM.
  d. Monitor voice radio.
  e. Blow whistle.
  f. Display signals.
  g. Inform captain of conditions; make recommendations.

VI. EXAMINE AND EVALUATE DATA INPUT FROM ALL SOURCES
  a. Consider effect of weather.
  b. Monitor wind speed and direction.
  c. Evaluate total data input during non-ship control emergency.
  d. Evaluate total data input during ship control emergency.
  e. Examine and evaluate total data input.

VII. SHIP CONTROL TASKS
  a. Hold ship's heading with hand steering.
  b. Change course of autopilot.
  c. Make change in rpm.
  d. Adjust throttle.
  e. Inspect equipment.
  f. Turn ship's helm and read compasses.
  g. Read course and speed indicators and alarms.
  h. Inform mate of speed and course change.

VIII. TASKS ASSOCIATED WITH CHANGING WATCH

a. Transfer information to mate on watch.

b. Transfer information to quarter master.

IX. MISCELLANEOUS TASKS

a. Keep log.

b. Write "night orders".

c. Perform miscellaneous tasks on bridge.

d. Take general notes.

RESTRICTED WATERS

I. VISUAL TASKS

a. Look out with binoculars.

b. Visually scan surrounding waters.

c. Keep watch for buoys and/or other markers (navigation).

d. Wait for navigational aids to pass abeam (navigation).

e. Detect - contacts and navigational aids (collision avoidance/navigation) visually.

f. Move to bridge wing.

g. Obtain visual ranges and bearings to aids.

II. ORDERS ISSUED BY THE PILOT

a. Convey navigation orders to others.

b. Issue any order to ensure safe operation.

c. Inform mate on watch of radio channel.

d. Issue commands to mate on watch for setting of ship's rpm.

e. Issue commands to helmsman for course changes.

f. Request mate on watch to raise various ship's flags.

g. Issue orders to mate on watch to drop anchor.

h. Stand by for orders from chief mate and carry out orders.

i. Issue anchor orders to chief mate, but clear most orders with captain.

j. Issue anchor orders as requested by pilot to chief mate.

III. TASKS INVOLVING THE USE OF NAVIGATIONAL HARDWARE

a. Operate radar and fathometer for hazard and aid detection.

b. Compare gyro and magnetic compasses and record the difference

c. Use radar to find range to navigational aids.

d. Take Loran data, two or three stations.

e. Plot Loran data, two or three stations.

f. Acquire Decca fix, data three stations.

g. Reset Decca chain.

h. Use radio direction finder.

i. Obtain electronic indications of position.
j. Take visual bearings with pelorus.
k. Take sun azimuth deviation.
l. Acquire alphanumeric contact or navigational data from CAS.
m. Switch between relative and true vector.
n. Maintain a position fix on ship.
o. Study intended track (navigation).
p. Perform various chart work.
q. Update knowledge of ship's position in respect to charted courses.
r. Check charts for navigational markers and look out for them.
s. Plot course on charts.
t. Plot satellite and navigational data on chart.
u. Make miscellaneous navigational calculations.
v. Plot Decca fix data.
w. Read compasses.

IV. COLLISION AVOIDANCE TASKS

a. Monitor CAS.
b. Silence alarm.
c. Adjust and tune radar or CAS.
d. Keep lookout with radar.
e. Actuate radar.
f. Reflection plot one, two, or more points on radar.
g. Acquire one, two or more contacts on CAS.
h. Delete one or two contacts on CAS.
i. Erase reflection plots.
j. Determine range and bearing of contacts on radar.
k. Perform trial maneuver on CAS.
l. Conduct all radar tasks.
m. Use straight edge to find CPA of reflection plot.
n. Monitor other ship's or own ship's movements.
o. Decide avoidance techniques.
p. Survey for other traffic and inform pilot and/or mate on watch of contact.

V. COMMUNICATION TASKS

a. Monitor voice radio.

b. Communicate with pilot ship or other source on ETA at various points as well as request information.

c. Set radio to pilot's requested channel.

d. Set radio to specific local channel.

e. Transmit ship-to-shore.

f. Transmit VTS.

g. Receive - active and/or passive.

h. Use sound powered phone.

i. Use channel 13 VHF.

j. Use multichannel VHF FM.

k. Call to own ship VHF FM.

l. Use walkie-talkie.

m. Use dial phone.

n. Listen for radio, horn, or bell.

o. Talk to helmsman, mate, engineer, and other personnel.

p. Blow whistle.

q. Display signals.

r. Order actuation of bells and/or switches.

s. Discuss contacts and navigation situation.

t. Transmit ship-to-ship.

u. Actuate radio.

VI. LOG KEEPING TASKS

a. Log pilot request for rpm change and time.

b. Log time ship is abeam various charted navigational markers.

c. Perform numerous inspections and log results.

d. Perform standard log duties.

e. Set engine order telegraph and log in bell book.

VII. EXAMINE AND EVALUATE DATA INPUT FROM ALL SOURCES

a. Monitor weather and sea state.

b. Evaluate total data input during non-ship control emergency.

c. Evaluate total data input during ship control emergency.
d. Monitor total operation of all personnel.
e. Monitor wind direction and speed.
f. Examine and evaluate total data input.

VIII. SHIP CONTROL TASKS

a. Shift from manual steering to autopilot.
b. Change course of autopilot.
c. Visually observe rudder angle.
d. Hold ship's heading with hand steering.
e. Adjust throttle.
f. Receive orders for course change, acknowledge and implement.
g. Set or adjust ship's rpm.
h. Actuate helm equipment.
i. Actuate telegraph.
j. Read course and speed indicators and alarms.
k. Turn ship's helm and read compasses.
l. Make speed or course changes.
m. Read turn rate indicator.
n. Read tachometer.

IX. TASKS ASSOCIATED WITH CHANGING WATCH

a. Transfer information at change of watch (mates).
b. Transfer information at change of watch (quartermaster).

X. TASKS REQUIRED TO RECOVER FROM CRITICAL INCIDENTS

a. Recover from collision with ship, boat, fishing vessel, tug-tow.
b. Recover from grounding/collision with shoal, buoy.
c. Recover from equipment failures.
d. Recover from fire.
e. Recover from ramming dock.

XI. MISCELLANEOUS TASKS

a. Take general notes.

b. Look at clock.

c. Perform tasks requiring sitting, standing, and/or walking about bridge.

d. Turn ship's lights on or off.

e. Stand by with anchor detail.

f. Fill in noon position report.

g. Write night orders.

h. Handle pilot launch alongside.

i. Inform pilot of ship's draft and maneuvering speed.

j. Acknowledge ship's draft, maneuvering speed, course and rpm; then assume pilot duties.

DOCKING/MOORING

a. Visually scan waters around berth.
b. Operate radar and fathometer for hazard and aid detection.
c. Monitor wind direction and speed.
d. Read course and speed indicators and alarms.
e. Monitor voice radio.
* f. Determine anchor drop range or bearing.
g. Examine and evaluate total data input.
h. Convey navigation orders to other personnel.
i. Adjust ship's rpm.
j. Turn ship's helm.
* k. Use mooring lines, anchor chain, etc.
l. Communicate with tugs, linehandlers, etc.
m. Sound whistle and display signals.
n. Monitor collision avoidance system.
o. Assess vessel traffic near berth.
p. Evaluate total data input during non-ship control emergency.
q. Evaluate total data input during ship control emergency.
r. Inform docking pilot of ship's draft and maneuvering speed.
s. Monitor total operation of all personnel.
t. Survey continuously for other traffic.
u. Receive knowledge of draft and maneuver speed.
v. Take over pilot duties.
w. Inform mate on watch of desired radio channel.
x. Issue commands to chief mate on lines to tug/pier.
y. Issue commands to tugs.
z. Monitor other traffic, distance to pier, etc.
aa. Issue steering commands to helmsman.
bb. Issue speed orders to mate on watch.
cc. Issue orders to line handlers on pier.
dd. Use experience to feel out ship.
ee. Set radio to channel requested by pilot and monitor transmissions; inform pilot of any calls.

ff. Log departure time, line secure time, pilot's name, etc.

gg. Set ship's rpm as requested by pilot.

hh. Log all pilot's requests for rpm change and time of request.

ii. Monitor rpm indicator and adjust throttle to sustain requested rpm.

jj. Inform engine room when finished with engines (i.e., docked).

kk. Relay line orders from pilot to bow and stern.

ll. Monitor lines and integrate bow and stern line handling.

mm. Give line orders based on observation.

nn. Communicate with chief mate regarding handling of bow and stern lines.

oo. Direct line handling by deck crew.

pp. Respond to steering orders from pilot.

qq. Implement line handling orders as given by mate.

* MOORING ONLY

CASUALTY SITUATION

The following situations are considered as casualties, but may not all be applicable to each of the following four categories: (1) man overboard, (2) fire, (3) collision, or (4) flooding.

I. SHIP CONTROL

a. Maneuver vessel.

b. Issue orders to bridge personnel.

c. Avoid other ship contacts.

d. Avoid unintentional grounding.

e. Minimize wind, sea and current effect on casualty.

f. Minimize effect of loss of propulsion, steering, visibility and/or stability on ship control.

g. Monitor ship control indicators.

h. Evaluate proper maneuvers to minimize casualty and assist in correcting situations.

i. Receive reports from bridge personnel.

j. Anchor ship.

k. Ground ship.

l. Avoid hazards.

II. NAVIGATION

a. Obtain visual fixes.

b. Operate electronic equipment.

c. Receive reports from bridge personnel.

d. Issue orders to bridge personnel.

e. Obtain electronic fixes.

f. Plot all fixes.

g. Maintain continuous track.

h. Evaluate effect of wind, current and sea conditions.

i. Order plotting of small boat if employed.

III. COLLISION AVOIDANCE

a. Issue orders to bridge personnel.

b. Receive reports from bridge personnel.

c. Evaluate contact movement.

d. Operate radar or CAS.

e. Plot contact movement.

f. Visually observe contact movement.
g. Evaluate own ship/contact relative motion.
h. Perform trial maneuver on CAS.
i. Monitor performance of bridge personnel.

IV. COMMUNICATIONS

a. Operate bridge radios (transmit and receive).
b. Order display of signal flags and shapes.
c. Order sounding of proper audio signals.
d. Observe signals from other ships.
e. Order signals by flashing light.
f. Evaluate effect of environment on signal capabilities.
g. Evaluate alternate methods of communication if casualty situation requires.
h. Receive reports from bridge personnel.
i. Monitor performance of bridge personnel.
j. Monitor communications.
k. Order display of navigation lights.
l. Issue orders to bridge personnel.

V. CASUALTY CONTROL

a. Call away proper casualty control party.
b. Review ship's emergency bill.
c. Determine extent of casualty.
d. Order corrective action by crew members.
e. Monitor actions of crew members.
f. Order employment of proper damage control equipment.
g. Receive reports.
h. Order operation of ship systems to control casualty.
i. Order restoration of material casualties.
j. Order jettisoning or offloading as required.
k. Order ballasting or counter flooding as required.
l. Request external assistance.
m. Order grounding if necessary.
n. Provide medical care.

VI. SEAMANSHIP

a. Order course and speed changes to assist in lowering and recovering small boat.

b. Order manning of small boat.

c. Issue instructions to boat officers.

d. Issue orders to employ small boats to maximum advantage.

e. Monitor performance of ship personnel.

f. Monitor performance of small boat personnel.

g. Receive reports from ship personnel.

h. Order lowering of small boat.

i. Order recovery of small boat.

j. Order "abandon ship" if required.

EXHIBIT A-2

TASK ANALYSIS SUMMARY

TABLE A-2-1. OPEN SEA TASKS

TASKS	1	2	3	4											SHIP TYPE					PERSON								
OPEN SEA	EA	EB	UNIV. OF WASH.	ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
Hold Ships Heading with Hand Steering	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2				1		2[E]			[A]EA Computer printout.
Lookout W/Binoculars in Wheelhouse	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2				1	1		2		[B]Dry Bulk Carrier
Use Sound Powered Phone	X				1	1		1					1	1		1	1				X	1	1	1				[C]Mate on watch. General Category.
Move to Bridge Wing	X				1	1		1					1	1		1	1						1	1				
Logging Function	X	X			1,2	1,2	2	1,[illegible]				2	1,2	1		1	1		2			1		1,2[C]				[D](Master) General Category.
Use Multichannel VHF FM	X				1	1		1					1	1		1	1				X		1	1				[E](Helmsman) General Category.
Misc. tasks requiring walking about bridge	X				1	1		1					1	1		1	1					1	1					[F]All #1 represent Task Flow Diagrams.
Wait for navigational aids to pass abeam (wheelhouse)	X				1	1		1					1	1		1	1							1				[G]Bridge Personnel.
Use radar to find range to navigational aid	X				1	1		1					1	1		1	1					1	1	1				
Plot navigation fix in chart rm	X				1	1		1					1	1		1	1					1	1	1				
Keep lookout with Radar #1	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2			1	1	1,2[C]				
Work in chart rm	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2		2[D]	1	1	1				
Change course of auto pilot	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2				1	1	2[E]			
Qtr. Masters Change Watch	X				1	1		1					1	1		1	1							1				
Call to own ship VHF FM	X				1	1		1					1	1		1	1				X			1				

TABLE A-2-1. OPEN SEA TASKS (CONT'D)

TASKS OPEN SEA	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Mate Relief Change Watch	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2			1		1,2[C]				
Loran, take Data 3 Stations	X				1	1		1					1	1		1	1					1	1	1				
Loran, take Data 2 Stations	X				1	1		1					1	1		1	1					1	1	1				
Plot Loran Data 3 Stations	X				1	1		1					1	1		1	1					1	1	1				
Plot Loran Data 2 Stations	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2			1	1	1,2[C]				
Plot Sat. Naviga-tion Data on chart	X				1	1		1					1	1		1	1					1		1				
Bow Lookout Reports Contact	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2			1	1	1	2			
Reflection Plot 1 Point on Radar	X				1	1		1					1	1		1	1					1	1	1				
Reflection Plot 2 Points on Radar	X				1	1		1					1	1		1	1					1		1				
Acquire 1 contact on CAS	X				1	1		1					1	1		1	1						1	1				
Acquire 2 contacts on CAS	X				1	1		1					1	1		1	1							1				
Delete 1 contact on CAS	X				1	1		1					1	1		1	1							1				
Adjust and tune radar or CAS	X				1	1		1					1	1		1	1							1				
Keep lookout w/CAS	X			X	1,4	1,4		1,4	4	4	4		1,4	1		1,4	1						1	1	2[E]		4[C]	
Qtr. Master re-ports contacts	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2				1	1	2			
Determine bearing and range on radar	X				1	1		1					1	1		1	1					1						
Erase reflection plots	X				1	1		1					1	1		1	1					1		1				

TABLE A-2-1. OPEN SEA TASKS (CONT'D)

TASKS OPEN SEA	1 EA	2 ER	3 UNIV. OF WASH.	4 URI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Take sea azimuth deviation		X			2	2	2	2				2	2						2					2^C				
Blow whistle				X	4	4		4	4	4	4		4			4					X						4^C	
Misc. Nav. calculations in chart room	X				1	1		1					1	1		1	1						1					
Fathometer reading				X	1	4		4	4	4	4		4			4											4^C	
Lookout time	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2		2^C	1		2^C				
Weather		X			2	2	2	2				2	2						2		2			2^C				
Informs mate of speed and course change		X			2	2	2	2				2	2						2		2							
Observe other or own ship's movements		X		X	2,4	2,4	2	2,4	4	4	4	2	4,2				4		2		2						4^C	
Write "Night Orders"		X			2	2	2	2				2	2						2		2							
Inspection of equipment		X			2	2	2	2				2	2						2		X			2^C				
Order Helmsman to change course		X			2	2	2	2				2	2						2		X			2^C				
Checks position plotted by mate		X			2	2	2	2				2	2						2		2			2^C				
Captain reports contact		X			2	2	2	2				2	2						2		2							
Informs Captain of conditions, makes recommendations		X			2	2	2	2				2	2						2					2^C				
Decides avoidance techniques		X			2	2	2	2				2	2						2		X			2^C				
Makes change in RPM		X		X	2,4	2,4	2	2,4	4	4	4	2	2,4			4			2		X			2^C			4^C	
Adjusts throttle		X			2	2	2	2				2	2						2					2^C				

TABLE A-2-1. OPEN SEA TASKS (CONT'D)

TASKS OPEN SEA	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI.	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OBD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Compares gyro and magnetic compasses		X			2	2	2	2				2	2						2					2^C				
Studies intended track				X	4	4		4	4	4	4		4			4					X						4^G	
Visually scan surrounding waters				X	4	4		4	4	4	4		4			4					X						4^G	
Operates radar for hazard and aid detection				X	4	4		4	4	4	4		4			4											4^G	
Obtains electronic indications of position				X	4	4		4	4	4	4		4			4											4^G	
Monitors wind direction and speed				X	4	4		4	4	4	4		4			4					X						4^G	
Reads course and speed indicators and alarms				X	4	4		4	4	4	4		4			4											4^G	
Monitors voice radio				X	4	4		4	4	4	4		4			4					X						4^G	
Examines and evaluates total data input				X	4	4		4	4	4	4		4			4					X						4^G	
Conveys navigation orders to other personnel				X	4	4		4	4	4	4		4			4					X						4^G	
Turns ships helm and reads compasses				X	4	4		4	4	4	4		4			4											4^G	
Displays signals				X	4	4		4	4	4	4		4			4											4^G	

TABLE A-2-1. OPEN SEA TASKS (CONT'D)

TASKS OPEN SEA	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Evaluate total data input during non-ship control emergency				X	4	4		4	4	4	4		4			4					X						4^G	
Evaluate total data input during ship control emergency				X	4	4		4	4	4	4		4			4					X						4^G	
General note	X				1	1		1					1	1		1	1					1	1	1				
Silence alarm	X				1	1		1					1	1		1	1					1						
Acquire alpha-numeric contact or Nav. data from CAS	X				1	1		1					1	1		1	1				X	1						
Obtains visual ranges and bearings to aids				X	4	4		4	4	4	4		4			4											4^G	

TABLE A-2-2. RESTRICTED WATERS TASKS

TASKS RESTRICTED WATERS	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL
Pilot launch alongside	X				1	1		1					1	1		1	1					1		1			4^G
Studies intended track				X	4	4		4	4	4	4		4			4				X							4^G
Visually scans surrounding waters			X	X	3,4	4		3,4	4	4	4		3,4	3		3,4	3	3		3	3						4^G
Operates radar and fathometer for hazard and aid detection	X			X	1,4	1,4		1,4	4	4	4		1,4	1		1,4	1			X		1		1			4^G
Obtain visual ranges and bearings to aids				X	4	4		4	4	4	4		4			4				X							4^G
Obtains electronic indications of position				X	4	4		4	4	4	4		4			4				X							4^G
Monitors wind direction and speed				X	4	4		4	4	4	4		4			4				X	X						4^G
Read course and speed indicators and alarms				X	4	4		4	4	4	4		4			4				X	X						4^G
Monitors voice radio				X	4	4		4	4	4	4		4			4				X	X						4^G
Examines and evaluates total data input				X	4	4		4	4	4	4		4			4				X	X						4^G
Conveys navigation orders to others				X	4	4		4	4	4	4		4			4				X							4^G
Adjusts ships RPM		X	X	X	2,3 4	2,4	2	2,3 4	4	4	4	2	2,3 4	3		3,4	3	3	2					E,C B,2			4^G
Turns ships helm and reads compasses				X	4	4		4	4	4	4		4			4											4^G

COMMENTS

[A] EA & Univ. of Wash. computer printout.

[B] Dry bulk carrier

[C] Mate on Watch. General category.

[D] All #1,#3 represent Task Flow Diagram.

[E] Mate on Watch with Pilot onboard.

[F] Chief Mate with pilot onboard.

[G] Bridge personnel

[H] Anchor detail.

[*] With Pilot onboard.

TABLE A-2-2. RESTRICTED WATERS TASKS (CONT'D)

TASKS RESTRICTED WATERS	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Displays signals (flags)				X	4	4		4	4	4	4		4			4											4^G	
Monitors CAS	X			X	1,4	1,4		1,4	4	4	4		1,4			1,4	1			1		1	1	1			4^G	
Evaluates total data input during non-ship control emergency				X	4	4		4	4	4	4		4			4				X	X						4^G	
Evaluates total data input during ship control emergency				X	4	4		4	4	4	4		4			4				X	X						4^G	
Informs Pilot of ships draft and maneuvering speeds		X			2	2	2	2				2	2						2		2*							
Writes "Night Orders"		X			2	2	2	2				2	2						2		2,2*							
Performs various chart work	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2		1,2*	1	1	1				
Updates knowledge of ship's position in respect to charted course		X			2	2	2	2				2	2						2	X	2,2*							
May make speed or course changes	X	X	X		1,2 3	1,2	2	1,2 3				2	1,2 3	1,3		1,3	1,3	3	2		2,2*	1	1	1,3				
Monitors other & own ships' movements		X		X	2,4	2,4	2	4,2	4	4	4	2	4,2			4			2	X	2,2*						4^G	
Surveys for other traffic and informs Pilot and/or Mate on Watch of contact	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2		2,2*	1	1	1,2		1		

TABLE A-2-2. RESTRICTED WATERS TASKS (CONT'D)

TASKS RESTRICTED WATERS	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Monitors total operation of all personnel		X	X		2,3	2	2	2,3				2	2,3	3		3	3	3	2		2,2* 3							
May issue any order to insure safe operation		X	X		2,3	2	2	2,3				2	2,3	3		3	3	3	2	3	2*,3							
Acknowledge ship's draft, maneuvering speed, course, and RPM; then assumes Pilot duties		X			2	2	2	2				2	2						2	2								
Informs Mate on Watch of radio channel he would like; then he communicates with pilot ship or other source on ETA at various points as well as request information		X			2	2	2	2				2	2						2	2								
Keeps watch for other traffic and makes decisions for avoidance of other contacts		X	X		2,3	2	2	2,3				2	2,3	3		3	3	3	2	2,3				2^C				
Keeps watch for buoys and/or other markers		X			2	2	2	2				2	2						2	2	X			2^C				
Issues commands to Mate on Watch for setting of ship's RPM		X			2	2	2	2				2	2						2	2								

TABLE A-2-2. RESTRICTED WATERS TASKS (CONT'D)

TASKS RESTRICTED WATERS	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Issues commands to Helmsman for course changes		X			2	2	2	2				2	2						2	2				2^C				
Requests the Mate on Watch to raise various ship's flags		X			2	2	2	2				2	2						2	2								
Issues orders to drop anchor to Mate on Watch		X			2	2	2	2				2	2						2	2								
Sets radio to the Pilot's requested channel		X			2	2	2	2				2	2						2					2^E				
Maintains a position fix on ship (utilizing various markers and equipment and marks position on chart)	X	X			1,2	1,2	2	1,2				2	1,2	1		1	1		2			1	1	2^C 2^E				
Checks charts for navigation markers so he can be on the lookout for them	X	X	X		1,2 3	1,2	2	1,2 3				2	1,2 3	1,3		1,3	1,3	3	2	3		1	1	$1,2^E$ 2^C				
Logs Pilot request for RPM change and time		X			2	2	2	2				2	2						2					2^E				
Logs time ship is abeam various charted navigational markers. Also fills in "Noon Position Report"		X			2	2	2	2				2	2						2					$2^C,2^E$				

TABLE A-2-2. RESTRICTED WATERS TASKS (CONT'D)

TASKS RESTRICTED WATERS	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Issues anchor orders as requested by Pilot to Chief Mate		X			2	2	2	2				2	2						2		X			2^E				
Compares gyro and magnetic compass and records the difference		X			2	2	2	2				2	2						2					$2^C,2^E$				
Performs numerous inspections. May log results.		X			2	2	2	2				2	2						2					$2^C,2^E$				
Turns ships lights on or off		X			2	2	2	2				2	2						2					$2^C,2^F$				
Performs standard log duties	X	X	X		1,2 3	1,2	2	1,2 3				2	1,2 3	1,3		1,3	1,3	3	2			1	1	3 $1,2^C$ 2^E				
Stands by with Anchor Detail		X			2	2	2	2				2	2						2					2^F				
Receives orders for course change, acknowledge, and implements		X			2	2	2	2				2	2						2						2*			
Adjust and tune radar or CAS	X				1	1		1					1	1		1	1			1		1	1	1				
Stands by for orders from Chief Mate and carries out orders		X			2	2	2	2				2	2						2								2^H	
Plots course on charts		X			2	2	2	2				2	2						2					2				
Sets radio to specific local channel and communicates ETA at various points		X			2	2	2	2				2	2						2	X			2^C					

TABLE A-2-2. RESTRICTED WATERS TASKS (CONT'D)

TASKS RESTRICTED WATERS	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Adjusts throttle		X			2	2	2	2				2	2						2					2^c				
Issues anchor orders to Chief Mate, but clears most orders through Captain		X			2	2	2	2				2	2						2	X				2^c				
Tasks requiring sitting, standing and/or walking	X		X		1,3	1		1,3					1,3	1,3		1,3	1,3	3		1,3	1,3	1	1	1,3				
Visual activity outside by degree (0,90,270,180)			X		3			3					3	3		3	3	3		3	3							
Lookout with binoculars	X		•		1,3	1		1,3					1,3	1,3		1,3	1,3	3		1,3	1,3	1	1	1				
Keep lookout with radar (#1 or #2)	X		X		1,3	1		1,3					1,3	1,3		1,3	1,3	3		1,3	1,3	1	1	1,3				
Talking to Helmsman, Mate, Engineer and other personnel			X		3			3					3	3		3	3	3		3	3							
Transmit Ship-to-Ship			X		3			3					3	3		3	3	3		3								
Transmit Ship-to-Shore			X		3			3					3	3		3	3	3		3								
Listen for radio, horn, or bell			X		3			3					3	3		3	3	3						3				
Actuate equipment on helm			X		3			3					3	3		3	3	3							3			
Actuate telegraph			X		3			3					3	3		3	3	3						3				
Actuate radar			X		3			3					3	3		3	3	3						3				
Actuate radio			X		3			3					3	3		3	3	3		3								

TABLE A-2-2. RESTRICTED WATERS TASKS (CONT'D)

TASKS RESTRICTED WATERS	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Order actuate bell and/or switches			X		3			3					3	3		3	3	3		3								
Blow whistle	X		X	X	4,1,3	4,1		1,3,4	4	4	4		1,3,4	1,3		4,1,3	1,3	3		3	1						4G	
Operator change watch (Mate and/ or Qtr. Master)	X		X		1,3	1		1,3					1,3	1,3		1,3	1,3	3				1	3,1	3,1				
Transmit VTS			X		3			3					3	3		3	3	3		3								
Receive - active and/or passive			X		3			3					3	3		3	3	3		3								
Look at clock			X		3			3					3	3		3	3	3		3	3							
Rudder angle (visually observe)	X		X		1,3	1		1,3					1,3	1,3		1,3	1,3	3		3			1	1	1			
Reads compasses			X		3			3					3	3		3	3	3		3								
Command control, weather and sea state			X		3			3					3	3		3	3	3		3	3							
Critical incident (ship, boat, fishing vessel, tug-tow)			X		3			3					3	3		3	3	3		3	3							
Critical incident shoal, buoy			X		3			3					3	3		3	3	3		3	3							
Critical incident equipment failure			X		3			3					3	3		3	3	3		3	3							
Critical incident fire			X		3			3					3	3		3	3	3		3	3							
Critical incident dock			X		3			3					3	3		3	3	3		3	3							
Holds ships heading with hand steering	X				1	1		1					1	1		1	1					1	1	1	1			

TABLE A-2-2. RESTRICTED WATERS TASKS (CONT'D)

TASKS RESTRICTED WATERS	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Use sound powered phone	X				1	1		1					1	1		1	1				1	1	1	1				
Wait for nav. aids to pass abeam (wheelhouse)	X				1	1		1					1	1		1	1			X		1	1	1				
General note	X				1	1		1					1	1		1	1			1	1	1	1	1	1			
Set EOT, log in bell book	X				1	1		1					1	1		1	1					1	1	1				
Use channel 13 VHF	X				1	1		1					1	1		1	1			1		1		1				
Move to bridge wing	X				1	1		1					1	1		1	1			1	1	1	1	1				
Use multichannel VHF FM	X				1	1		1					1	1		1	1			1		1	1					
Shifts from manual steering to auto pilot	X				1	1		1					1	1		1	1							1				
Use radar to find range to nav. aid	X				1	1		1					1	1		1	1			1		1	1	1				
Loran, take Data 2 or 3 Stations	X				1	1		1					1	1		1	1			X		1	1					
Change course of auto pilot	X				1	1		1					1	1		1	1					1	1	1				
Call to own ship VHF FM	X				1	1		1					1	1		1	1			X				1				
Plot Loran Data 2 or 3 Stations	X				1	1		1					1	1		1	1			X		1	1					
Plot sat., nav. data on chart	X				1	1		1					1	1		1	1			X		1		1				
Reflection plot (1), (2), or more than (2) points on radar	X				1	1		1					1	1		1	1			X		1	1	1				

TABLE A-2-2. RESTRICTED WATERS TASKS (CONT'D)

TASKS RESTRICTED WATERS	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Acquire (1) contact on CAS	X				1	1		1					1	1		1	1			X		1	1	1				
Acquire (2) contacts on CAS	X				1	1		1					1	1		1	1			X				1				
Acquire more than (2) contacts on CAS	X				1	1		1					1	1		1	1			X		1						
Delete (1) contact on CAS	X				1	1		1					1	1		1	1			X				1				
Delete (2) contacts on CAS	X				1	1		1					1	1		1	1			X		1						
Determine range and bearing of contacts on radar	X				1	1		1					1	1		1	1			X		1	1	1				
Erase reflection plots	X				1	1		1					1	1		1	1			X			1	1				
Takes visual bearings pelorous	X				1	1		1					1	1		1	1			X		1	1	1				
Take sun azimuth deviation	X				1	1		1					1	1		1	1					1						
Use walkie talkie	X				1	1		1					1	1		1	1			X		1	1					
Misc. nav. calculations	X				1	1		1					1	1		1	1					1	1	1				
Use straight edge to find CPA of reflection plot	X				1	1		1					1	1		1	1					1	1	1				
Lookout time-contacts and nav. aids	X				1	1		1					1	1		1	1					1	1	1				
Use dial phone	X				1	1		1					1	1		1	1				1	1	1	1				
Acquire Decca fix Data 3 Station	X				1	1		1					1	1		1	1			X		1	1	1				

TABLE A-2-2. RESTRICTED WATERS TASKS (CONT'D)

TASKS RESTRICTED WATERS	1 EA	2 UB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
Plot Decca fix data in chart rm	X				1	1		1					1	1		1	1			X		1	1	1				
Silence alarm	X				1	1		1					1	1		1	1					1	1	1				
Acquire alpha-numeric contact or navigation data from CAS	X				1	1		1					1	1		1	1			1		1	1	1				
Verbal discussions about contacts and nav. situation	X				1	1		1					1	1		1	1			1	1	1	1	1				
Trial maneuver on CAS	X				1	1		1					1	1		1	1			1								
Switch between relative and true vector	X				1	1		1					1	1		1	1			1								
Reset Decca chain	X				1	1		1					1	1		1	1			X			1					
Radio direction finder	X				1	1		1					1	1		1	1			X		X						
All radar tasks (specific actions hidden from observer)	X				1	1		1					1	1		1	1			1		1	1	1				
Observe turn rate indicator	X				1	1		1					1	1		1	1			1	X							
Observe tachometer	X				1	1		1					1	1		1	1			1								

TABLE A-2-3. MOORING TASKS

MOORING TASKS	1 EA	2 ER	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PERSON: PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
Informs Pilot of ship's draft and maneuvering speed																					X							
Continuously monitors performance of all personnel																					X							
Monitors other traffic in docking area																					X							
Receives knowledge of draft and maneuver speed																				X								
Take over Pilot duties																				X								
Informs Mate on Watch of desired radio channel																				X								
Issues commands to Chief on lines to tug/pier																				X								
Issues commands to tugs																				X								
Monitors other traffic, distance to pier, etc.																				X								
Issues steering commands to Helmsman																				X								
Issues speed orders to Mate on Watch																				X								

TABLE A-2-3. MOORING TASKS (CONT'D)

	1	2	3	4											SHIP TYPE					PERSON								
TASKS MOORING	EA	EB	UNIV. OF WASH.	ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
Issues orders to line handlers on pier																					X							
Utilized experience to feel out ship																					X							

TABLE A-2-4. OPEN SEA CASUALTIES TASKS

TASKS OPEN SEA CASUALTIES	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
A. Ship Control																												
1. Maneuver vessel																					X							
2. Issue orders to bridge personnel																					X							
3. Avoid other ship contacts																					X							
4. Avoid unintentional grounding																					X							
5. Minimize wind, sea and current effect on casualty																					X							
6. Minimize effect of loss of propulsion, steering, visibility and/or stability on ship control																					X							
7. Monitor ship control indicators																					X							

TABLE A-2-4. OPEN SEA CASUALTIES TASKS (CONT'D)

TASKS OPEN SEA CASUALTIES	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
8. Evaluate proper maneuvers to minimize casualties and assist in correcting situation																					X							
9. Receive reports from bridge personnel																					X							
10. Anchor Ship																					X							
11. Ground ship																					X							
12. Avoid hazards																					X							
B. Navigation 1. Obtain visual fixes																					X							
2. Operate electronic equipment																					X							
3. Receive reports from bridge personnel																					X							
4. Issue orders to bridge personnel																					X							
5. Obtain electronic fixes																					X							

TABLE A-2-4. OPEN SEA CASUALTIES TASKS (CONT'D)

TASKS OPEN SEA CASUALTIES	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PERSON: PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
6. Plot all fixes																					X							
7. Maintain continuous track																					X							
8. Evaluate the effect of wind, current, & sea conditions																					X							
9. Order plotting of small boat if employed																					X							
C. Collision Avoidance																												
1. Issue orders to bridge personnel																					X							
2. Receive reports from bridge personnel																					X							
3. Evaluate contact movement																					X							
4. Operate radar or CAS																					X							
5. Plot contact movement																					X							
6. Visually observe contact movement																					X							

TABLE A-2-4. OPEN SEA CASUALTIES TASKS (CONT'D)

TASKS OPEN SEA CASUALTIES	1	2	3	4											SHIP TYPE					PERSON								COMMENTS
	EA	LB	UNIV. OF WASH.	ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	
7. Evaluate own ship/contact relative motion																					X							
8. Perform trial maneuver on CRS																					X							
9. Monitor performance of bridge personnel																					X							
D. Communications																												
1. Operate bridge radios (transmit and receive																					X							
2. Order display of signal flags and shapes																					X							
3. Order sounding of proper audio signals																					X							
4. Observe signals from other ships																					X							
5. Order signals by flashing light																					X							

TABLE A-2-4. OPEN SEA CASUALTIES TASKS (CONT'D)

TASKS OPEN SEA CASUALTIES	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BW LOOKOUT	PERSON: GENERAL	COMMENTS
6. Evaluate the effect of environment on signal capabilities																					X							
7. Evaluate alternate methods of communication if casualty situation requires																					X							
8. Receive reports from bridge personnel																					X							
9. Monitor performance of bridge personnel																					X							
10. Monitor communications																					X							
11. Order display of navigation lights																					X							
12. Issue orders to bridge personnel																					X							

TABLE A-2-4. OPEN SEA CASUALTIES TASKS (CONT'D)

TASKS OPEN SEA CASUALTIES	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
E. Casualty Control																												
1. Call away proper casualty control party																					X							
2. Review ship's emergency bill																					X							
3. Determine the extent of casualty																					X							
4. Order corrective action by crew members																					X							
5. Monitor actions of crew members																					X							
6. Order employment of proper damage control equipment																					X							
7. Receive reports																					X							
8. Order operation of ship systems to control casualty																					X							

TABLE A-2-4. OPEN SEA CASUALTIES TASKS (CONT'D)

TASKS OPEN SEA CASUALTIES	1 EA	2 RB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	USD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PERSON: PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
9. Order restoration of material casualties																					X							
10. Order jettisoning or off-loading as required																					X							
11. Order ballasting or counter-flooding as required																					X							
12. Request external assistance																					X							
13. Order grounding if necessary																					X							
14. Provide medical care																					X							
F. Seamanship																												
1. Order course & speed changes to assist in lowering and recovering small boat																					X							

TABLE A-2-4. OPEN SEA CASUALTIES TASKS (CONT'D)

TASKS OPEN SEA CASUALTIES	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	USD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
2. Order manning of small boat																					X							
3. Issue instruction to boat officers																					X							
4. Issues orders to employ small boats to maximize advantage																					X							
5. Monitor performance of ship personnel																					X							
6. Monitor performance of small boat personnel																					X							
7. Receive reports from ship personnel																					X							
8. Order lowering of small boat																					X							
9. Order recovery of small boat																					X							
10. Order "abandon ship" if required																					X							

TABLE A-2-5. RESTRICTED WATERS CASUALTIES TASKS

TASKS RESTRICTED WATERS CASUALTIES	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
A. Ship Control																												
1. Maneuver vessel																				X								
2. Issue orders to bridge personnel																				X	X							
3. Avoid other ship contacts																				X								
4. Avoid unintentional grounding																				X								
5. Minimize wind, sea and current effect on casualty																				X								
6. Minimize effect of loss of propulsion, steering, visibility on ship control																				X								
7. Monitor ship control indicators																				X	X							
8. Evaluate proper maneuvers to minimize casualty and assist in correcting situation																					X							

TABLE A-2-5. RESTRICTED WATERS CASUALTIES TASKS (CONT'D)

TASKS RESTRICTED WATERS CASUALTIES	1 EA	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
9. Receive reports from bridge personnel																				X	X							
10. Anchor ship																				X								
11. Ground ship																				X								
12. Avoid hazards																				X								
B. Navigation																												
1. Obtain visual fixes																				X								
2. Operate electronic equipment																					X							
3. Receive reports from bridge personnel																				X	X							
4. Issue orders to bridge personnel																				X	X							
5. Obtain electronic fixes																					X							
6. Plot all fixes																					X							
7. Maintain continuous track																				X	X							

TABLE A-2-5. RESTRICTED WATERS CASUALTIES TASKS (CONT'D)

	1	2	3	4											SHIP TYPE					PERSON								
TASKS RESTRICTED WATERS CASUALTIES	MA	EB	UNIV. OF WASH.	ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
8. Evaluate the effect of wind, current, & sea conditions																				X								
9. Order plotting of small boat if employed																					X							
C. Collision Avoidance																												
1. Issue orders to bridge personnel																				X	X							
2. Receive reports from bridge personnel																				X	X							
3. Evaluate contact movement																				X	X							
4. Operate radar or CAS																					X							
5. Plot contact movement																					X							
6. Visually observe contact movement																				X								
7. Evaluate own ship/contact relative motion																				X								

TABLE A-2-5. RESTRICTED WATERS CASUALTIES TASKS (CONT'D)

	1	2	3	4											SHIP TYPE					PERSON								
TASKS RESTRICTED WATERS CASUALTIES	IA	EB	UNIV. OF WASH.	ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
8. Perform trial maneuver on CAS																					X							
9. Monitor performance of bridge personnel																				X	X							
D. Communications																												
1. Operate bridge radios (transmit and receive)																				X								
2. Order display of signal flags and shapes																				X								
3. Order sounding of proper audio signals																				X								
4. Observe signals from other ships																				X								
5. Order signals by flashing light																				X								
6. Evaluate the effect of environment on signal capabilities																				X								

TABLE A-2-5. RESTRICTED WATERS CASUALTIES TASKS (CONT'D)

		2	3	4											SHIP TYPE					PERSON								
TASKS RESTRICTED WATERS CASUALTIES	EA	EB	UNIV. OF WASH.	ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
7. Evaluate alternate methods of communication if casualty situation requires																				X	X							
8. Receive reports from bridge personnel																				X	X							
9. Monitor performance of bridge personnel																				X	X							
10. Monitor communications																				X								
11. Order display of navigation lights																				X	X							
12. Issue orders to bridge personnel																					X							
E. Casualty Control																												
1. Call away proper casualty control party																												

TABLE A-2-5. RESTRICTED WATERS CASUALTIES TASKS (CONT'D)

TASKS	1	2	3	4											SHIP TYPE					PERSON								
RESTRICTED WATERS CASUALTIES	EA	ER	UNIV. OF WASH.	ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
2. Review ship's emergency bill																					X							
3. Determine the extent of casualty																					X							
4. Order corrective action by crew members																					X							
5. Monitor actions of crew members																					X							
6. Order employment of proper damage control equipment																					X							
7. Receive reports																				X	X							
8. Order operation of ship systems to control casualty																					X							
9. Order restoration of material casualties																					X							

TABLE A-2-5. RESTRICTED WATERS CASUALTIES TASKS (CONT'D)

TASKS RESTRICTED WATERS CASUALTIES	1	2	3	4											SHIP TYPE					PERSON								
	EA	ER	UNIV. OF WASH.	ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	VLCC	SMALL TO MEDIUM TANKER	CONTAINER	PASSENGER	GENERAL	PILOT	MASTER	FIRST MATE	SECOND MATE	THIRD MATE	HELMSMAN	BOW LOOKOUT	GENERAL	COMMENTS
10. Order jettisoning or off loading as required																					X							
11. Order ballasting or counter-flooding as required																					X							
12. Request external assistance																					X							
13. Order grounding if necessary																				X	X							
14. Provide medical care																					X							
F. Seamanship																												
1. Order course and speed changes to assist in lowering and recovering small boat																				X								
2. Order manning of small boat																					X							
3. Issue instructions to boat officers																					X							

TABLE A-2-5. RESTRICTED WATERS CASUALTIES TASKS (CONT'D)

TASKS RESTRICTED WATERS CASUALTIES	1 [illegible]	2 EB	3 UNIV. OF WASH.	4 ORI	FREQUENCY	TIME DURATION	CRITICALITY	% OF TOTAL WORKLOAD	PERFORMANCE MEASURES	PERFORMANCE STANDARDS	SKILLS AND KNOWLEDGE	OSD	FUNCTIONAL FLOW	OTHER	SHIP TYPE: VLCC	SHIP TYPE: SMALL TO MEDIUM TANKER	SHIP TYPE: CONTAINER	SHIP TYPE: PASSENGER	SHIP TYPE: GENERAL	PERSON: PILOT	PERSON: MASTER	PERSON: FIRST MATE	PERSON: SECOND MATE	PERSON: THIRD MATE	PERSON: HELMSMAN	PERSON: BOW LOOKOUT	PERSON: GENERAL	COMMENTS
4. Issue orders to employ small boats to maximize advantage																					X							
5. Monitor performance of ship personnel																					X							
6. Monitor performance of small boat personnel																					X							
7. Receive reports from ship personnel																				X	X							
8. Order lowering of small boat																					X							
9. Order recovery of small boat																					X							
10. Order "abandon ship" if required																					X							

EXHIBIT A-3

AN OVERVIEW OF PORT XYZ

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OVERVIEW OF PORT XYZ

A. SERVICES
   1. Radio Harbor Traffic Control
   2. Radar Harbor Traffic Control
   3. Tugs
   4. Pilots
   5. Fuel water, garbage, electrical (housekeeping)
   6. Medical (PHS) (quarantine)
   7. Plant and animal inspection
   8. Weather reporting and forecasting
   9. Customs
   10. Port of Entry (Immigration)
   11. Coast Guard
       a. Safety inspections
       b. Captain of the port
       c. SAR capability
          (1) Communications
          (2) Air
          (3) Surface
       d. Pollution control
       e. Aid to navigation maintenance
   12. Traffic routing
   13. Docking facilities
       a. Linehandlers
       b. Cargo handlers and equipment

B. TURNING BASIN
   1. Dimensions
      a. Cushion and suction effects
      b. Limiting ship length and draft
   2. Depth
      a. Cushion and suction effect
      b. Topography
         (1) "Humps"
         (2) "Holes"
         (3) Shelves
   3. Type of bottom
      a. Holding ground
         (1) Rocky
         (2) Sand
         (3) Mud
         (4) Clay
      b. Large rocks
         (1) Cushion
         (2) Suction
   4. Traffic density (1-40 contacts)
      a. Barges
      b. Large ships
      c. Pleasure craft
   5. Number and types of berths
      a. Open versus closed piers
      b. Bulkheads

c. Slips
d. Wharves
6. Special weather and/or current conditions
a. Tidal bores
b. Williwaws
c. Tsunamis
d. River or channel effect

C. PILOTING
1. Navigation aids
a. Fixed
(1) Ranges
(a) Lighted
(b) Unlighted
(2) Lighthouses (50 - 150 ft)
(a) Danger bearings
(b) Characteristics of light
(c) Height (50 - 150 ft)
(d) Radar target
(1) Obstructed
(2) Clear
(3) Beacons
(a) Visual targets
(1) Obstructed
(2) Clear
(3) Lighted
(4) Unlighted
b. Floating
(1) Buoys
(a) Type
(1) Bell, gong, whistle
(2) Lighted
(3) Unlighted
(4) Spar
(5) Nun
(6) Can
(7) Radar reflector
(8) Color
(b) Use
(1) Channel
(2) Fairway
(3) Wreck or obstruction
(4) Sea (fairway)
(5) Mid-channel
(6) Mooring
(2) Lightship
(a) Characteristics
(b) General location
(c) Danger bearings
2. Landmarks
a. Natural
(1) Islands
(2) Bluffs
(3) Peninsula

(4) Mountain
(5) Rivers
b. Artificial
(1) Radio towers (100 - 300 ft)
(a) Lighted
(b) Unlighted
(2) Piers or breakwaters (50 x 1000 ft)
(a) Lighted
(b) Unlighted
(3) Buildings (50 - 300 ft)
(a) Obstructed
(b) Clear
(4) Smokestack (100 - 300 ft)
(a) Obstructed
(b) Clear
(c) Lighted
(d) Unlighted
(5) Water tanks (50 - 100 ft)
(a) Obstructed
(b) Clear
(c) Lighted
(d) Unlighted
(6) Bridge supports
(a) Lighted
(b) Unlighted
(c) Relationship to channel
(1) Width - 1.2 x channel width
(2) Height - 20 ft greater than height of vessel

3. Electronic
a. RDF
(1) Beacons
(a) Accuracy ($\pm 5^{\circ}$)
(b) Range (100 miles)
(2) Commercial radio station
(a) Inaccurate
(b) Atmospherics
(c) Station interference
b. Decca
(1) Range (actual)
(2) Accuracy (actual)
(3) Atmospherics
c. Omega
(1) Range (actual)
(2) Accuracy (actual)
(3) Atmospherics
d. Loran
(1) Range (actual)
(2) Accuracy (actual)
(3) Atomspherics

4. Sound
a. Foghorns
(1) Characteristic
b. Sirens
(1) Characteristics

D. HAZARDS

1. Submarine cables
   a. Telephone
   b. Power
   c. Direction laid
   d. Depth
   e. Buried
2. Fish nets and/or traps
   a. Fixed
   b. Temporary
3. Shoals
   a. Type of bottom
      (1) Rock
      (2) Mud
      (3) Sand
      (4) Coral
   b. Cushion and suction effects
4. Isolated rocks
   a. Configuration
   b. Limiting depth
   c. Cushion and suction effects
5. Wrecks
   a. Marked
   b. Unmarked
   c. Relationship to channel
6. Restricted or prohibited areas
   a. Unexploded weapons
   b. Cables or pipelines
   c. Interference with traffic
   d. Ferry lane
7. Pipelines
   a. Buried or clear
   b. Type
   c. Direction laid
   d. Depth (80 - 300 ft)
8. Disposal areas
   a. Dumping ground or spoil area
      (1) Type of material
      (2) Depth of water (200 - 600 ft)
         (a) Surveyed
         (b) Wire dragged
         (c) Sounded
      (3) Extent
9. Magnetic disturbances
   a. Mineral deposits
   b. Power effects
10. Ship traffic
   a. Density (1-40)
   b. Types
   c. Traffic patterns
   d. Control methods
      (1) Radio
      (2) Radar
      (3) Visual signals

11. Bridge structures
    a. Horizontal clearance 1.2 x channel width
    b. Vertical clearance (vessel height +20 ft)
    c. Wind (0 - 50 knots), current (0-5 knots), or tidal effects (0 - 20 ft)
12. Overhead cables and transmission lines
    a. Vertical clearance (vessel height +20 ft)
13. Aircraft flight patterns
14. Special (temporary)
    a. Dredging
    b. Placing navaids
    c. Work under construction
        (1) Breakwaters
        (2) Piers
        (3) Jetties

E. CHANNEL
1. Depth (80 - 150 ft)
2. Width (700 - 1000 ft)
3. Variable wind and current conditions
    a. Locations
    b. Velocity (wind: 0-50 knots; current: 0-5 knots)
    c. Direction
4. Configuration
    a. Dog legs
    b. Blind spots
    c. Sharp turning angles (10 - 120 degrees)
5. Navigational aids
    a. Buoys
    b. Ranges
    c. Landmarks

F. ENVIRONMENTAL FACTORS
1. Wind
    a. Prevailing
    b. Velocity (0 - 50 knots)
    c. Special conditions
        (1) Topographical effects
        (2) Seasonal effects
2. Tide and current
    a. Tidal range (0 - 20 ft)
        (1) Spring
        (2) Neap
    b. Current velocity range (0 - 5 knots)
        (1) Tidal influence
        (2) River flow effect
3. Snow and rain
    a. Seasonal duration
    b. Seasonal amounts
    c. River effect
4. Fog
    a. Season and percentage of time
5. Ice
    a. Seasonal duration (1 - 6 months)

b. Thickness in harbor (1 - 6 in.)
c. Extent of down river flow at breakup

G. ANCHORAGE
1. Restricted
a. Geography
(1) Limiting ship

H. MOORINGS
1. Piers
2. Wharves
3. Dolphins
4. Offshore platform and/or buoys

EXHIBIT A-4

CASUALTY DATA

SUMMARY OF CASUALTY DATA

For the past six consecutive years, as reported by the Liverpool Underwriters Association (Annual Report, 1977) tonnage totally lost has exceeded one million gross tons. Annual losses by tonnage for the years 1962 through 1977 appear in Figure A-4-1, and total losses in terms of number of ships in Figure A-4-2. Of that proportion of the one million gross tons which were totally lost due to collison and grounding during each consecutive year since 1971, Bovet (1973) has demonstrated statistically that 16 percent occur in harbors; 62 percent in approach waters including rivers and bays, and 22 percent in the open sea. Since the vast majority of collisions and groundings occur in restricted waters (i.e., 78 percent, comprising 16 percent harbors plus 62 percent approach waters), the specific functional objectives proposed for a shiphandling simulator training program are devoted to conning a ship in restricted waters under a broad range of circumstances. The direction taken by the proposed training program is in keeping with the need for upgrading shiphandling skills that apply to those situations defined by the casualty statistics.

For other variables dependent on situation, Cordell and Nutter (1976) have compiled both United States Naval and United States merchant ship statistics. The casualty statistics for the environmental variables investigated indicate that the majority of collisions and groundings occur (a) in clear visibility, (b) in the absence of precipitation, (c) with calm winds, (d) with less than 0.5-knot currents, and (e) within restricted waterways. The only difference between the two casualty situations is that collisions tend to occur during the day (on the afternoon watch) and groundings at night during the mid watch (0000 to 0400 hr).

Since these casualties occur under relatively ideal conditions, the investigators assessed the human factors responsible for collisions and groundings (Cordell and Nutter, 1976). Their findings have indicated that the majority of casualties occurred when the most highly qualified teams were on the bridge. From their analysis the primary sources of human failure were:

- Inadequate use of navigation aids for determining position

- Over-reliance on the pilot
- Failure to follow established bridge procedures
- Communications breakdown

The secondary most prominent human factor responsible for casualties was the failure on the part of the master to understand and compensate for both external and internal forces acting upon the ship.

As a result of these findings, training should be directed to develop the skills and knowledge of the master to understand the differing maneuver capabilities of ship types. Such shiphandling training is not proposed so that the pilot may be replaced, but to develop the skills of the master to competently take command during an emergency. The same sources of human error found to be responsible for grounding and collision casualties have been independently supported by other unpublished sources.*

This analysis of casualty statistics supplies the information necessary to determine those objectives that meet the needs of the maritime industry. Use of simulation for training shiphandling skills is thus consistent with the realistic need to improve safety and reduce casualty costs for the industry. The SFOs proposed for simulation training are, therefore, directly related to the needs and objectives of the marine community.

*Report on the Grounding and Collision Casualty Data Base Project, Marine Management Systems, Inc., 300 Broad Street, Stamford, Conn, 1976.

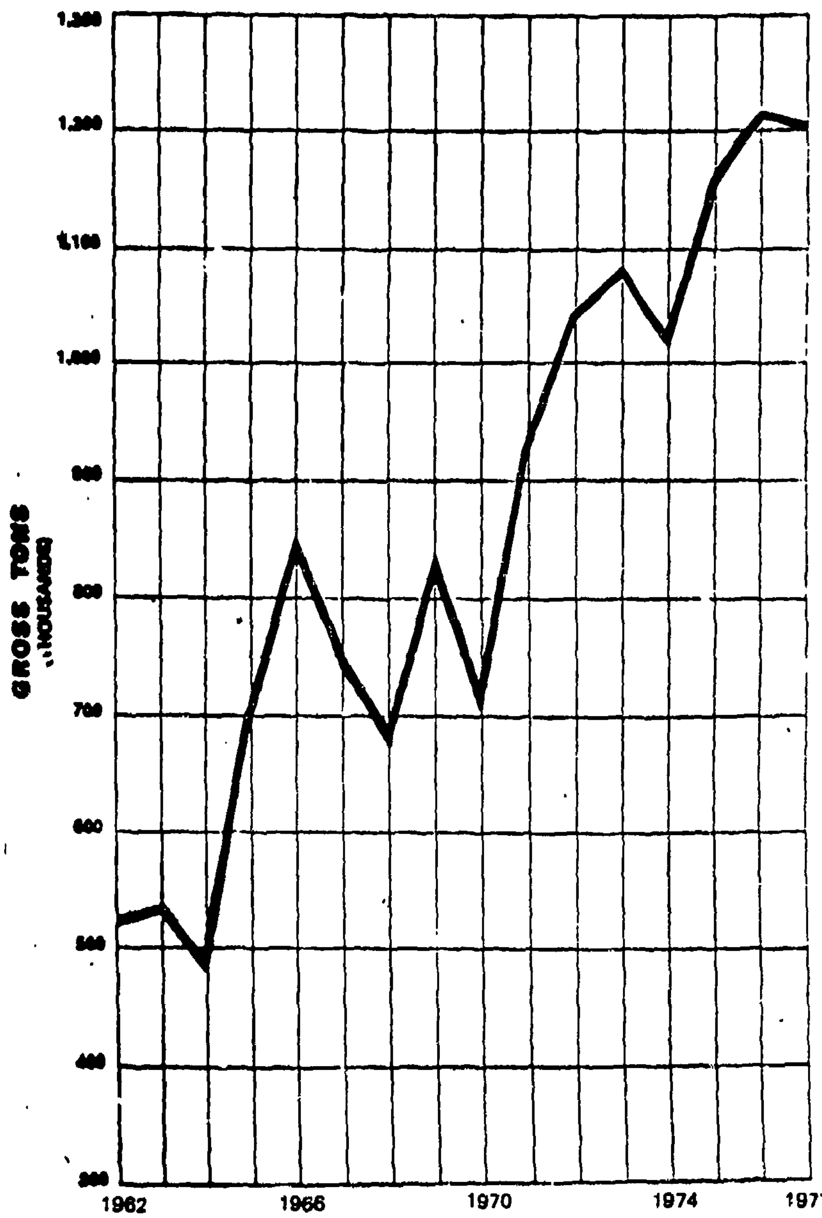

FIGURE A-4-1. ANNUAL LOSSES BY TONNAGE, 1962 - 1977

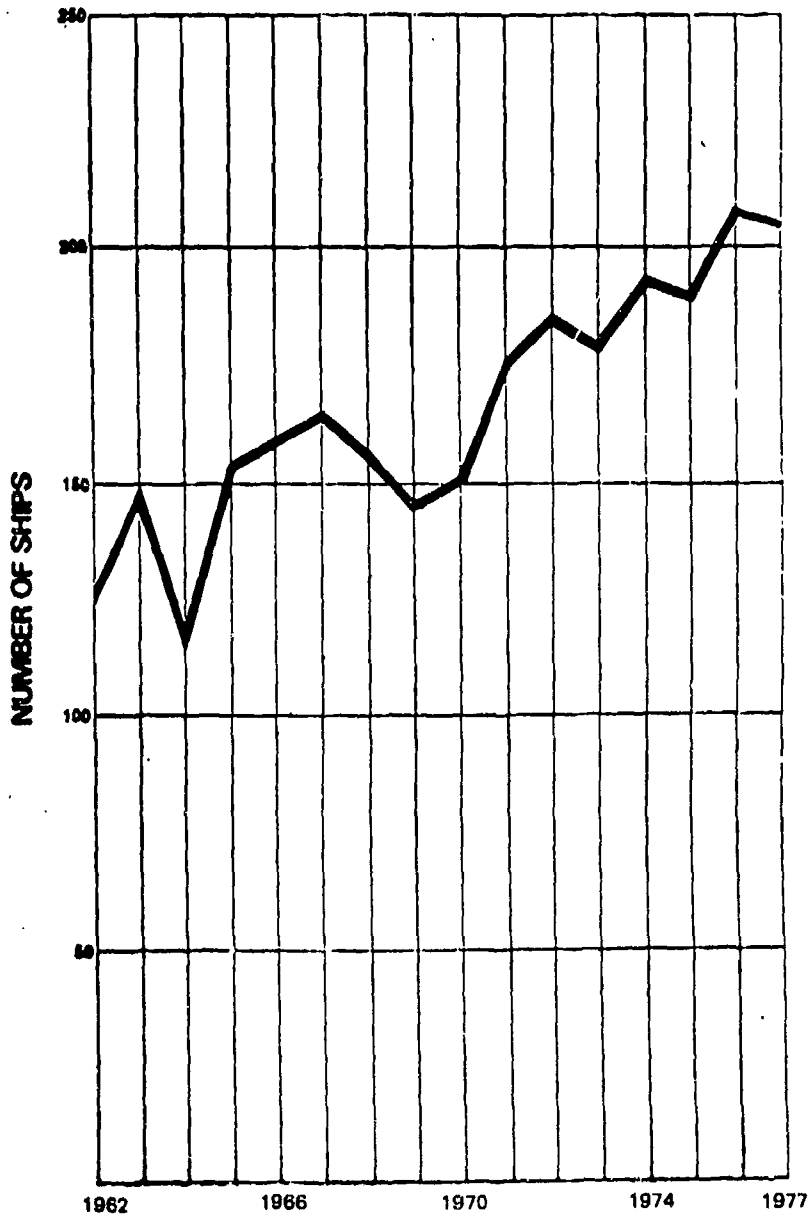

FIGURE A-4-2. TOTAL LOSSES IN NUMBER OF SHIPS, 1962 - 1977

EXHIBIT A-5

SKILL REQUIREMENTS

SKILL ITEMS

NAVIGATION

1. Study the intended track by determining the required heading and by identifying the use of navigational aids.

2. Obtain visual indications of position to update own ship's position in respect to charted courses by scanning and searching surrounding waters with binoculars to:
    a) recognize and evaluate ship contacts
    b) recognize navigational hazards and aids

3. Establish a bearing to a navigational aid using an azimuth circle.

4. Operate Loran A and C equipment to obtain navigational data; then read Loran charts and tables and plot Loran data for two or three stations.

5. Operate Decca equipment and plot Decca data from three stations.

6. Operate NAVSAT equipment, read and interpret NAVSAT tape readouts; plot data on charts.

7. Operate the RDF to obtain a bearing; plot this bearing on a mercator chart.

8. Operate a depth finder to determine water depth.

9. Calculate the difference between the readings of a magnetic and a gyro compass; correct the gyro.

10. Instruct the mate on watch to operate the EOT and set the propeller.

11. Read and interpret course and speed indicators and the turn rate indicator.

12. Receive reports from bridge personnel regarding these indicators; take appropriate action.

13. Write "night orders":
    a) standing orders
    b) special orders

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SKILL ITEMS

COMMUNICATION

14. Operate sound powered phone for:
    a) navigation
    b) watchstanding

15. Operate dial phone as required.

16. Operate and monitor walkie-talkie for:
    a) navigation
    b) watchstanding
    c) tug communication
    d) pilot boat

17. Operate and monitor VHF FM:
    a) VTS
    b) ship to ship
    c) ship to shore
    d) pilot boat
    e) emergency frequency

18. Transmit situation report and request assistance on the radio from other ships or the Coast Guard shore facilities.

19. Order the mate on watch to initiate external signals (i.e., whistle, signal flags, navigation lights, anchor lights, and shapes).

SKILL ITEMS

ENVIRONMENTAL ELEMENTS

20. Operate a radio facsimile recording system to obtain facsimile weather charts; read and interpret weather charts.

21. Decide whether to deviate from intended track on the basis of weather conditions.

22. Monitor present weather and forecast future weather using own ship's weather instruments:
    a) barometer
    b) thermometer (wet and dry bulb)
    c) anemometer

23. Obtain set and drift information from navigational fixes and pilot charts.

RADAR/CAS

24. Operate a radar unit interpreting the display when the following navigational hazards and aids are recognized:
    a) obstacles
    b) buoys
    c) ship contacts
    d) landmarks

25. Reflection plot on radar/CAS.

26. Operate, monitor, and interpret CAS to detect possible collision situations.

27. Perform a trial maneuver on CAS and decide correct avoidance techniques.

SKILL ITEMS

MANEUVERING

28. Maneuver the vessel around tight turns in the waterway, using a bow thruster.

29. Maneuver the vessel through the waterway, compensating for waterway effects such as suction, cushion, and drag; maintain a safe distance from other ships.

30. Maneuver the vessel to avoid obstructions in a waterway or seaway; maintain a safe distance from other ships.

31. Maintain position in own section of the waterway while maneuvering the vessel through the waterway; maintain a safe distance from other ship contacts.

32. Maneuver the vessel in an approach to/departure from the pilot station.

33. Maneuver the vessel through the waterway when given wind speeds of 0 to 50 knots from any direction.

34. Maneuver the vessel through the waterway when given current speeds of 0 to 5 knots from any direction.

35. Maneuver the vessel through the waterway when given tide heights of 1 to 20 ft (neap, ebb).

36. Maneuver the vessel through the waterway when given visibility conditions of 0 NM to unlimited.

37. Maneuver the vessel through ice, plotting continuous position.

38. Execute the following maneuvers using the appropriate turn sequence:
    a) Kempf (zig-zag)
    b) Spiral
    c) Williamson
    d) port or starboard

39. Evaluate the effects of the following ship characteristics on stopping distance, rate of turn, tactical diameter, etc:
    a) block coefficient
    b) power coefficient
    c) screw configuration
    d) rudder configuration
    e) loading conditions

SKILL ITEMS

DOCKING/MOORING/ANCHORING

40. Maneuver the vessel in an approach to an anchorage.

41. Correctly position the vessel in the anchorage; drop the anchor.

42. Commence the approach to the dock through the waterway, compensating for environmental and waterway effects.

43. Alert and direct tugs as to the number needed and the placement of each to assist in the docking operation.

44. Initiate the approach to a mooring buoy.

45. Correctly position the vessel to be moored.

46. Stop the vessel using:
    a) rudder cycling
    b) coasting stop
    c) full engine reverse

SKILL ITEMS

EMERGENCIES

47. Given conflicting information, decide the type of corrective action and the correct timing for such ship control actions.

48. Inspect mechanical and electrical equipment onboard the vessel.

49. Evaluate the cause of certain equipment failures and take corrective ship control action.

50. In a man overboard situation, maneuver the vessel to clear the man, remain in navigable waters, and maintain a lee side.

51. Maintain a navigational plot to provide SAR forces with location.

52. Maneuver the vessel to facilitate lifeboat recovery.

53. In a fire-on-board emergency, maneuver the vessel to compensate for possible loss of:
    a) propulsion
    b) steering
    c) stability

54. Evaluate the location, nature, and extent of the fire.

55. In time of emergency, decide whether to anchor or ground the vessel clear of the waterway to prevent sinking or control flooding.

56. Decide the appropriate action to take in an imminent collision situation.

57. Monitor and direct emergency efforts:
    a) employment of proper equipment
    b) dewatering and ballasting as required
    c) closure of watertight doors

58. Under emergency situations, maneuver the vessel to minimize damage before and/or after collision.

59. Maneuver the vessel to remain clear of other ship contacts in an emergency situation:
    a) visually ascertain course and speed of other ships
    b) perform relative motion calculations
    c) evaluate proper changes in own ship motion

SKILL ITEMS

EMERGENCIES (CONT'D)

60. Maneuver the vessel to resume intended course and speed.

61. Maneuver the vessel through the waterway maintaining ship control when a rudder failure occurs.

62. Given a particular restricted waters, open sea, or emergency situation, integrate any of the above skills once the relevant information has been collected, the data evaluated and the proper course of action determined.

EXHIBIT A-6

KNOWLEDGE REQUIREMENTS

KNOWLEDGE ITEMS

NAVIGATION

1. List and describe types of navigational aids (artificial aids) and natural landmarks to determine position.

2. Explain the desirability of fixed aids versus floating aids.

3. Describe the use of binoculars for visual lookout:

   a) adjustment
   b) method of scanning
   c) under adverse weather conditions

4. Describe the types of contacts and their effects on own ship.

5. Explain how navigational hazards could pose a threat to own ship.

6. Explain how to use an azimuth circle to obtain relative and/or true bearing.

7. Specify the procedure and terminology used to communicate the position of a contact.

8. Illustrate the procedures for plotting own ship position from visual indicators.

9. Explain how to determine the position of a navigational marker in regard to charted course and when such a marker will be visible.

10. Define intended track.

11. List the characteristics of a particular waterway.

12. State all facilities on the local pier.

13. Summarize the procedure used to check a position which has been plotted.

14. List all the ship characteristics that must be considered when issuing orders to insure safe navigation.

15. Describe any hazardous navigational situation that could exist and state the alternatives to insure safe operation.

16. Describe the process for:

    a) comparing a magnetic compass and a gyro compass.
    b) correcting gyro compass

17. State the causes of and procedures for determining gyro error.

18. Designate the procedure for operating and extrapolating information from electronic indicators to update own ship position.

19. Name the electronic aids available to own ship along a specific route.

20. Designate the capabilities of a particular depth finder.

21. Explain how to manipulate:

    a) depth scale on a depth finder
    b) intensity of a depth finder

22. Explain how to operate a radio direction finder.

23. Describe the process of determining bearings from the radio direction finder.

24. Describe how to read and interpret an RDF correction table.

25. State the procedure for plotting on a Mercator Chart, using correction.

26. Explain the operation of Loran A and C equipment.

27. Identify Loran station pairs.

28. Describe procedures for use of Loran charts and tables.

29. Describe method of plotting Loran data.

30. Describe limitations of the Loran system.

31. Explain the procedures to:

    a) operate the four Decca receivers
    b) read and interpret Decca charts

32. Describe the procedure for determining a position by using a decometer.

33. Define the reliable day and night ranges of Decca.

34. Delineate the average error in a line of position obtained by Decca.

35. Illustrate the correct procedure for plotting Decca fix data on Decca charts.

36. Describe the procedure for resetting Decca receivers.

37. Describe the procedure for operating NAVSAT equipment.

38. Explain the procedures to:

a) understand NAVSAT tape readouts
b) plot satellite data on charts

39. Explain chart distortion, grid variation, and scale of chart.

40. Identify symbols, abbreviations and scales used on charts and in publications.

41. Describe how to read NAVSAT charts and publications.

42. Explain how to relate charts to the actual physical environment.

43. List the specific rudder positions that can be employed, and state the effects on the maneuverability of own ship.

44. Explain how to read and interpret:

a) course and speed indicators and alarms
b) turn rate indicator

45. Explain the ship characteristics that are pertinent to course and/or rpm changes.

KNOWLEDGE ITEMS

COMMUNICATION

46. Summarize use of bridge radio:

    a) method of operation
    b) proper circuits to be used
    c) ship or stations to be called
    d) proper radio voice procedure

47. Delineate equipment/circuit usage for communication equipment.

48. Describe the operational procedures and terminology used in external radio communication.

49. State methods of communication with tugs, harbor control, and other ships.

50. Designate which flag should be used in particular navigational situations such as:

    a) general use
    b) emergency
    c) Rules of the Road
    d) identification

51. Summarize the various whistle signals.

52. Summarize the use of various shapes, whistles, flag signals, and lights signals under:

    a) Rules of the Road
    b) emergency situations

KNOWLEDGE ITEMS

ENVIRONMENTAL ELEMENTS

53. Summarize local wind and weather conditions - summarize all weather and sea-state data.

54. Explain how to manipulate a radio facsimile recording system.

55. Describe how to read and interpret weather charts.

56. Define the weather symbols used on charts.

57. Explain how to extract information from:

    a) weather instruments
    b) weather publications
    c) pilot charts to obtain general set and drift information

58. Describe the effect of the wind and current conditions on various hull configurations under specific loading conditions.

59. Describe the maneuvering capabilities of a particular vessel in a specific location as affected by environmental conditions and harbor traffic patterns.

KNOWLEDGE ITEMS

RADAR/CAS

60. Summarize the capabilities and limitations of radar/CAS.

61. Explain how to manipulate own ship radar controls for:

    a) various range scales
    b) sector selection
    c) intensity and gain
    d) elimination of sea return and ground clutter

62. Illustrate the operation of own ship radar/CAS.

63. State the procedure for transposing range circles and bearing lines.

64. Describe how to detect a navigational hazard or aid on a radar unit.

65. Describe the procedure for obtaining a range and bearing reading from radar.

66. Specify procedures for operating the radar/CAS unit to scan surrounding waters and monitor other or own ship movement.

67. Illustrate the methods of radar/CAS plotting.

68. Define relative vector, true vector and speed or vector triangle.

69. Explain the effect own ship movement has on relative motion.

70. Explain how to derive the following data from CAS:

    a) CPA
    b) time to CPA
    c) target range and bearing
    d) point of possible collision
    e) predicted area of danger

71. Summarize the decision making process in determining avoidance techniques.

KNOWLEDGE ITEMS

MANEUVERING

72. Explain when to initiate and how to execute tight turns in a restricted waterway using a bow thruster.

73. Explain the effect that cushion, suction, and drag have on a vessel's handling capabilities.

74. Summarize the factors to be considered when determining the plan of approach to pick up/drop off a pilot.

75. State how the following factors effect ship handling and describe compensatory procedures to overcome these effects:

    a) speed of current
    b) winds of 30 to 50 knots
    c) tides of greater than 10 ft
    d) limited visibility

76. Describe the procedure followed for navigating through ice.

77. Summarize the procedure for properly executing the following maneuvers:

    a) Kempf (zig-zag)
    b) Spiral
    c) Williamson turn

78. Define own ship characteristics:

    a) turning circle
    b) advance and transfer
    c) turning rate
    d) stopping distance
    e) rudder effect
    f) speed capability

79. State the relationships that exist among ancillary equipment, environmental factors and ship as they relate to ship controllability.

80. Describe own ship hydrodynamic characteristics as they may be effected by prevailing environmental conditions along the route, and the seasonal variations of those environmental conditions through the range of expected values.

DOCKING/MOORING/ANCHORING

81. Describe anchoring methods for:

    a) positioning
    b) ship control
    c) effect of wind, current and sea conditions
    d) emergency situations (i.e., collision, fire, loss of power)

82. Describe the procedure for approaching a single point mooring.

83. Describe the procedure for approaching a dock, using tug assistance.

84. Explain the factors involved in determining the number of tugs needed and the placement of each.

KNOWLEDGE ITEMS

EMERGENCIES

85. Describe equipments generally found on board ship which are involved in ship maneuverability, safety and communication.

86. Describe how ship control mechanical-electrical equipment on own ship operates as well as any possible malfunctions that could occur.

87. Summarize information needed to control fire pertaining to:

    a) ship systems

        1. CO_2
        2. steam smothering
        3. fire mains
        4. spray or steam curtains

    b) compartmentation
    c) water tight doors

88. Explain the method of safely launching and recovering a lifeboat.

89. Summarize signals for controlling lifeboats by:

    a) radio
    b) flashing light
    c) signal flags
    d) hand

90. Summarize and describe the types of failures that might effect ship control with recommended substitute action for:

    a) rudder failure
    b) electrical power failure
    c) propulsion failure

91. Explain the effects of failures on ship handling.

92. Explain the procedure for correcting any possible malfunctions that could occur.

93. Describe measures to be taken to minimize the effects of an imminent collision.

94. Describe various ship control engineering systems and their vulnerability to collision and/or flooding damage.

95. Define pertinent factors affecting stability.

96. Summarize the method of calculation for ballasting under emergency conditions.

97. Summarize international law regarding salvage rights.

98. Describe construction of own ship with emphasis on flooding control methods, alternate ship control and engineering systems available.

EXHIBIT A-7

INPUT CHARACTERISTICS

INPUT CHARACTERISTICS

MASTER OF 30,000 DWT TANKER

The following knowledge and skill requirements pertain to the characteristics of a tanker in the 30,000 to 80,000 dwt class.

A. NAVIGATION

A.1 Visual

KNOWLEDGE

*1. List and describe types of navigational aids (artificial aids) and natural landmarks used to determine a position fix.

2. Explain the desirability of fixed versus floating aids.

3. Describe the use of binoculars for visual lookout. Discuss adjustment, method of scanning, and use under adverse weather conditions.

4. Describe the types of contacts and their effects on own ship.

5. Explain how navigational hazards could pose a threat to own ship.

* 6. Explain how to use an azimuth circle to obtain relative and/or true bearing.

7. Specify the procedure and terminology used to communicate the position of a contact.

SKILLS

1. Obtain visual indications of position so as to update knowledge of own ship position in relation to charted courses. Observe visually any outside activity. Scan and search surrounding waters with binoculars to recognize and evaluate contacts, navigational hazards, and aids such as obstacles, shoals, and buoys.

2. Establish the visual range and bearing to navigational aids by using:

   a. azimuth circle (bearing)
   *b. radar (range and bearing).

*Items which are formal tasks required for licensing, as specified in "Specimen Examinations for Merchant Marine Deck Officers" (CG-101-1 and CG-101-2), and "Rules and Regulations for Licensing and Certificating of Merchant Marine Personnel" (CG-191).

INPUT CHARACTERISTICS

KNOWLEDGE	SKILLS
* 8. Illustrate the procedures for plotting own ship's position from visual indicators.	
9. Explain how to determine the position of a navigational marker in relation to a charted course and when such a marker will be visible.	

A.2 Intended track

KNOWLEDGE	SKILLS
10. Define intended track.	3. Study intended track to: a. locate fixed navigational aids b. analyze the selection of proper courses c. apply the effect of local wind and weather.
11. List the characteristics of a particular waterway.	
12. State all facilities on the local pier.	4. Check charts and identify the position of navigational marks (e.g., buoys, landmarks) in relation to intended track.
13. Summarize the procedure used to check a position that has been plotted.	5. Check the position plotted by the mate for accuracy.

A.3 Navigation Orders and Safety Considerations

KNOWLEDGE	SKILLS
14. List all the ship's characteristics that must be considered when issuing orders to ensure safe navigation.	6. Convey navigation orders to other personnel.
15. Describe any hazardous navigational situation possible and state the alternatives for safe operation in that situation.	7. Issue proper orders for safe navigation to: a. helmsman b. radar operator c. mate on watch.

INPUT CHARACTERISTICS

A.4 Gyro Compass

KNOWLEDGE	SKILLS
16. Describe the process for: a. comparing a magnetic compass and a gyro compass b. correcting a gyro compass.	* 8. Compare the reading of a magnetic compass and a gyro compass.
17. State the causes of and procedures for determining gyro error.	* 9. Calculate the difference between the two compass readings.
	*10. Correct the gyro compass.

A.5 Weather and Sea State

KNOWLEDGE	SKILLS
18. Summarize local wind and weather conditions. Summarize all weather and sea-state data.	11. Operate a radio facsimile recording system to obtain facsimile weather charts.
19. Explain how to manipulate a radio facsimile recording system.	12. Read and interpret weather charts.
*20. Describe how to read and interpret weather charts.	13. Listen to weather broadcasts, choosing the proper station.
*21. Define the weather symbols used on charts.	14. Decide whether or not to deviate from intended track on the basis of weather conditions.
22. List the radio stations that regularly broadcast weather.	15. Monitor present weather and forecast future weather using own ship's weather instruments: a. barometer b. thermometer (wet and dry bulb) c. anemometer.
*23. Explain how to extract information from weather instruments, weather publications, and pilot charts to obtain general set and drift information.	16. Obtain set and drift information from: a. taffrail log b. navigation fixes c. pilot charts.
*24. Describe the effect of wind and current conditions on various hull configurations under specific loading conditions.	
25. Describe the maneuvering capabilities of a particular vessel in a specific location as affected by environmental conditions and harbor traffic patterns.	

INPUT CHARACTERISTICS

B. ELECTRONIC INDICATIONS OF POSITION

KNOWLEDGE

26. Designate the procedure for operating and extrapolating information from electronic indicators to update own ship position.
27. Name the electronic aids available to own ship along a specific route.

B.1 Radar

28. Summarize the capabilities and limitations of radar.
29. Explain how to manipulate own ship radar controls for:
    a. various range scales
    b. sector selection
    c. intensity and gain, and
    d. elimination of sea return and ground clutter.
30. Illustrate the operation of own ship radar.
31. State the procedure for transposing range circles and bearing lines.
32. Describe how to detect a navigational hazard or aid on a radar unit.
33. Describe the procedure for obtaining a range and bearing reading from radar.
34. Specify procedures for operating the radar unit to scan surrounding waters and monitor the movement of other ships or own ship.
35. Illustrate the methods of radar plotting.

SKILLS

17. Obtain electronic indications of position so as to update knowledge of own ship position in respect to charted course using:
    *a. radar
    b. depth finder
    c. radio direction finder.

*18. Operate a radar unit.

*19. Recognize the following navigational hazards and navigational aids on radar:
    a. obstacles
    b. buoys
    c. contacts
    d. landmarks
    e. shoals.

*20. Evaluate range and bearing of a navigational hazard and/or navigational aid from radar unit.

*21. Scan surrounding waters with radar for navigation hazard and aid detection; detect hazards and aids.

22. Inform pilot and/or mate on watch of contact.

*23. Monitor movements of own ship or other ship using radar.

24. Switch from relative to true vector on radar.

25. Switch from true to relative vector on radar.

KNOWLEDGE	SKILLS
*36. Define relative vector, true vector, and speed or vector triangle.	*26. Reflection plot on radar.
37. Describe the procedure for changing between relative and true vector.	*27. Erase reflection plots.
*38. Explain the effect own ship's movement has on relative motion.	
39. Summarize the decision-making process in determining avoidance techniques.	

B.2 Depth Finder

KNOWLEDGE	SKILLS
*40. Designate the capabilities of a particular depth finder.	28. Determine water depth by operating a depth finder.
*41. Explain how to manipulate the depth scale and intensity of a depth finder.	

B.3 Radio Direction Finder

KNOWLEDGE	SKILLS
*42. Explain how to operate a radio direction finder.	29. Operate the radio direction finder to obtain a bearing.
*43. Describe the process of determining bearings from the radio direction finder.	30. Plot RDF bearing on a Mercator chart.
*44. Describe how to read and interpret an RDF correction table.	
*45. State the procedure for plotting on a Mercator chart (using correction factor).	

B.4 Loran

KNOWLEDGE	SKILLS
*46. Explain the operation of Loran A and C equipment.	31. Operate Loran A and C equipment to obtain navigation data.

KNOWLEDGE	SKILLS
*47. Identify Loran station pairs.	32. Demonstrate ability to read Loran chart and tables.
*48. Describe procedures for use of Loran charts and tables.	33. Plot Loran data for two or three stations.
*49. Describe the method of plotting Loran data.	
*50. Describe limitations of the Loran system.	
B.5 <u>Decca</u>	
*51. Explain how to operate the four Decca receivers and how to read and interpret Decca charts.	34. Demonstrate ability to operate Decca equipment.
*52. Describe the procedure for determining a position by using a decometer.	35. Plot Decca data from three stations.
*53. Define the reliable day and night ranges of Decca.	36. Reset Decca chain.
*54. Delineate the average error in a line of position obtained by Decca.	
*55. Illustrate the correct procedure for plotting Decca fix data on Decca charts.	
*56. Describe the procedure for resetting Decca receivers.	
B.6 <u>NAVSAT</u>	
*57. Describe the procedure for operating NAVSAT equipment.	37. Operate NAVSAT equipment.
*58. Describe the procedures for: a. understanding NAVSAT tape readouts b. plotting satellite data on charts.	38. Read and interpret NAVSAT tape readouts.
	39. Plot NAVSAT data on charts.

KNOWLEDGE

*59. Explain chart distortion, grid variation, and scale of chart.

*60. Identify symbols, abbreviations, and scales used on charts and in publications.

*61. Describe how to read NAVSAT charts and publications.

62. Explain how to relate charts to the actual physical environment.

C. COMMUNICATION

63. List the particular radio stations available in a certain area.

64. Summarize the use of bridge radio relating to:

a. method of operation
b. proper circuits to be used
c. ships or stations to be called
d. proper voice procedure.

SKILLS

C.1 Internal

40. Operate and monitor walkie-talkie for:

a. navigation
b. watchstanders
c. tug
d. pilot ship.

41. Operate dial telephone as required.

KNOWLEDGE		SKILLS	

C.2 External

KNOWLEDGE		SKILLS	
65.	Delineate equipment/circuit usage for communication equipment.	42.	Operate and monitor VHF FM (voice radio): a. VTS b. ship to ship c. ship to shore d. pilot ship e. emergency frequency.
66.	Describe the operational procedures and terminology used in external radio communication.	43.	Monitor ship to ship and ship to lifeboat communications.
*67.	State methods of communication with tugs, harbor control, and other ships.	44.	Monitor harbor traffic visually and on harbor radio (VTS) circuit.
68.	Designate which flag should be used in particular navigational situations (emergencies, Rules of the Road, identification and general use).	*45.	Order the mate on watch to initiate external signals (i.e., whistle, signal flags, navigation lights, anchor lights, and shapes).
69.	Summarize the various whistle signals.		
70.	Summarize the use of various shapes, whistles, flag signals, and lights signals under Rules of the Road and in emergency situations.		

D. SHIP CHARACTERISTICS

KNOWLEDGE		SKILLS	
*71.	Define own ship characteristics as a function of: a. a turning circle b. advance and transfer operations c. turning rate d. stopping distance e. wind and current under various loading conditions f. water depth g. proximity to shoals and piers.	46.	Receive ship readiness report from master and act accordingly, as to: a. equipment status b. ship operating characteristics c. special information regarding ship indicators communication and control systems, and alarms along with the location of each d. ship's draft, trim, dimensions, and "hog" and "sag" characteristics under existing ballast conditions.

KNOWLEDGE	SKILLS
*72. State the relationships that exist among ancilliary equipment, environmental factors, and the ship as they relate to ship controllability.	
*73. Describe own ship hydrodynamic characteristics as they may be affected by prevailing environmental conditions along the route, and the seasonal variations of those environmental conditions through the range of expected values.	
*74. Explain the following ship characteristics: a. speed capability b. rudder effect c. stopping distance d. topographical effects e. effects of shallow water.	

E. ANCHORING/DOCKING

E.1 <u>Change Course</u>

KNOWLEDGE	SKILLS
*75. Explain the ship characteristics pertinent to course and/or rpm changes.	47. Order personnel to operate EOT and set propeller rpm. 48. Order the helmsman to change course.

E.2 <u>Anchoring</u>

KNOWLEDGE	SKILLS
*76. Describe anchoring methods in relation to: a. positioning b. ship control c. effect of wind, current, and sea conditions d. emergency situations (i.e., collision, fire, loss of power).	49. Order personnel to drop anchor.

KNOWLEDGE		SKILLS	
	E.3 Docking		
*77.	Describe power and maneuverability capabilities of tug.	50.	Issue commands to line handlers on pier.
		51.	Issue orders to personnel on line to: a. tugs b. pier.
	F. SHIP CONTROL/NON-SHIP CONTROL EMERGENCIES		
*78.	Specify when and how to use regulations, conventions, principles, and Rules of the Road.	52.	Examine and evaluate total data input in accordance with the particular situation to determine: a. non-ship control emergency b. ship control emergency c. normal watchstanding routine.
*79.	Explain the use of various corrective methods necessary to control and minimize emergencies under varying conditions.		
80.	Describe formation and use of ship's emergency watch bill.	53.	Decide the type of corrective action and the correct timing for such action in varying emergencies.
*81.	List operations and/or duties performed by the following personnel in any given emergency situation: a. mate (day work) b. mate on watch c. master d. helmsman e. bow lookout f. anchor detail.	54.	Construct a personnel emergency bill outlining duties for each person.
		55.	Monitor total operation of all personnel.
82.	Name the personnel who interact in performing certain emergency tasks (See 81, above)		
83.	State when certain emergency tasks should be performed (See 81, above).		

KNOWLEDGE	SKILLS

F.1 Equipment Failures

KNOWLEDGE	SKILLS
*84. Describe equipments generally found on board ship which are involved in ship maneuverability, safety, and communication.	56. Inspect mechanical and electrical equipment onboard the vessel.
*85. Describe operation and possible malfunctions of ship control mechanical/electrical equipments on own ship.	57. Evaluate the causes of certain equipment failures (See 56, above) and take corrective ship control action.
*86. Explain the use, capability, and limitations of the equipment (See 85, above) as it affects shiphandling.	58. Take corrective action to repair or replace failed equipment.
*87. Summarize and describe the types of rudder, electrical power, and propulsion failures that might affect ship control. Give recommended substitute actions.	
*88. Explain the effects of failures on shiphandling.	
*89. Explain the procedure for correcting any possible malfunctions.	

F.2 Dial Indicators

KNOWLEDGE	SKILLS
90. Designate how to read rudder position.	59. Read the rudder angle indicator.
91. List the specific rudder positions available and state the effects on the maneuverability of own ship.	60. Read and interpret: a. course and speed indicators and alarms b. turn rate indicator.
92. Explain how to read and interpret: a. course and speed indicators and alarms b. turn rate indicator.	61. Receive reports from bridge personnel regarding these indicators and take appropriate action.

G. MAN OVERBOARD

KNOWLEDGE	SKILLS
93. Describe lookout reporting procedure. *94. Describe methods used for continuous navigational plotting, using: a. dead reckoning b. set and drift c. bearing and distance to known object d. two bearings on one object with run between bearings. 95. Explain the method of safely launching and recovering a lifeboat. 96. Summarize signals for controlling lifeboats by: a. radio b. flashing light c. signal flags d. hand. *97. List the various types of lifesaving equipment on board own ship and explain how to use that equipment under varying conditions.	62. In a man overboard situation, conn the vessel to clear the man and remain in navigable waters: a. order heading, rudder, and speed changes b. maintain lee side c. maintain navigable position. 63. Transmit situation report on the radio to: a. other ships b. Coast Guard shore facilities. 64. Conn the vessel to remain clear of other ships in an emergency situation: a. visually ascertain contact's course and speed b. perform relative motion calculations c. evaluate proper changes in own ship motion d. use radar to track contacts e. make avoidance decisions in a timely manner. 65. Order lookout to report the relative position of the man overboard. 66. In emergency situations, maintain a navigation plot to: a. remain in navigable water b. avoid ship contacts c. provide SAR forces with location d. monitor movement of other ships.

KNOWLEDGE	SKILLS
	67. In emergency situations maintain a navigational plot by: a. visual means b. electronic means c. dead reckoning.
	68. Order man overboard party called away.
	69. Designate proper lifeboats to be swung out, cleared, and lowered for appropriate emergency situations.
	70. Instruct boat officer on: a. location of man b. ship traffic c. weather conditions d. future ship movements e. weather and sea state.
	71. Maneuver ship to facilitate lifeboat recovery: a. provide lee side rescue b. avoid running down own ship's boat or man c. avoid other ship contacts.
	72. Recover man overboard party: a. monitor action by ship personnel in bringing boat alongside b. monitor securing and lifting of boat aboard ship c. provide medical care for rescued man.
	73. Conn the vessel to resume intended course and speed.
	74. In a man overboard situation, call away more lookouts to keep the man in sight.

KNOWLEDGE

SKILLS

75. Direct lifeboat in water via:

   a. radio
   b. flashing lights
   c. masthead lights
   d. hand signals.

H. FIRE ON BOARD

KNOWLEDGE

*98. Identify fire hazards that exist on board vessels.

99. Summarize information needed to control fire pertaining to:

   a. ship systems
      (1) CO_2
      (2) steam smothering
      (3) fire mains
      (4) spray or steam curtains
   b. compartmentation
   c. watertight doors.

*100. Define the tyes of fires and the proper methods of combatting these fires:

   a. wood and paper - Class A
   b. inflammable liquid - Class B
   c. electrical - Class C.

*101. State which extinguishers to use for which type of fire:

   a. soda and acid type (quench fire)
   b. foam type (smothering effect)
   c. carbon tetrachloride (nonconductive agent).

SKILLS

76. In a fire-on-board emergency, conn the vessel to:

   a. remain in navigable waters
   b. avoid other ship contacts
   c. minimize wind and sea effect
   d. compensate for possible loss of:
      (1) propulsion
      (2) steering
      (3) visibility
      (4) stability.

77. Order fire party called away.

78. Evaluate location, nature, and extent of fire.

79. Conn the vessel to minimize fire damage.

80. Monitor and direct fire fighting efforts:

   a. order additional personnel
   b. order employment of proper equipment
   c. order the operation of fixed fire fighting systems
   d. order dewatering and ballasting as required
   e. order closure of watertight doors
   f. order tanks flooded to prevent spread of fire.

KNOWLEDGE

102. Summarize the type of assistance available from external sources:

a. other ships
b. tugs
c. Coast Guard.

*103. Demonstrate use of first aid techniques for:

a. drowning
b. fracture
c. head injuries
d. exposure
e. excessive bleeding
f. burns.

SKILLS

81. Request external help via:

a. radio
b. flashing light
c. signal flags and shapes.

82. Decide type and amount of assistance required from:

a. other ships
b. tugs
c. Coast Guard (air and surface).

83. Order jettisoning or offloading of cargo if necessary.

84. Provide medical care as required.

I. COLLISION AND/OR FLOODING

*104. Describe measures to be taken to minimize the effects of an imminent collision.

*105. Describe various ship control engineering systems and their vulnerability to collision and/or flooding damage.

*106. Define pertinent factors affecting stability.

*107. Summarize the method of calculation for ballasting under emergency conditions.

*108. Summarize international law regarding salvage rights.

*109. Describe construction of own ship with emphasis on flooding control methods, and alternate ship control and engineering systems available.

85. In time of emergency, decide whether to anchor or ground ship clear of the channel to prevent sinking or to control flooding.

86. Anchor or ground ship clear of the channel to prevent sinking or control flooding.

87. Execute "abandon ship" if required.

88. Under emergency situations, conn the ship to:

a. minimize damage
b. recover personnel
c. remain clear of ship contacts
d. anchor or ground vessel if necessary
e. clear channel.

KNOWLEDGE	SKILLS
	89. Order damage control party called away.
	90. Evaluate extent of damage of own or other vessel.
	91. Recommend maneuvers to pilot to minimize flooding.
	92. Monitor and direct damage control party: a. order additional personnel to scene b. order employment of proper equipment c. order closing of watertight doors d. order dewatering of flooded compartment, voids, holds, or tanks e. order counterballasting as necessary.
	93. Receive reports from bridge personnel.

EXHIBIT A-8

SPECIFIC FUNCTIONAL OBJECTIVES

Specific Functional Objectives

This set of specific functional objectives (SFO) represent highly detailed objectives to be achieved as a result of the particular training program. Each SFO is comprised of two segments:

1) Conditions which describe the circumstances under which behavior should be performed; and
2) Behavior which is the specific skill and/or knowledge to be attained by the master as a result of training and/or experience. (See A-5 for skill requirements and A-6 for knowledge requirements).

Conditions

Fourteen conditions were established to incorporate all possible situations which could exist while maneuvering the vessel in restricted waters. These conditions apply to each of the functional objectives specified below unless otherwise stated.

A. Varying degrees of visibility:

   1) Visibility limited to own ship's bow
   2) 0-1 mile
   3) 2-5 miles
   4) Unlimited

B. Specific geographical constraints of varying complexity:

   1) Channel width
      a. Minimum of 700 ft
      b. 1200 ft
      c. 1500 ft
   2) Varying channel depths-minimum of two (2) feet below the keel of the ship
   3) Geographical obstacles both visible and submerged.

C. Ship Traffic:

   1) None
   2) Light (1-5 contacts)
   3) Medium (6-10 contacts)
   4) Heavy (over 10)

D. Varying environmental conditions:

   1) Wind
      a. 0-10 knots
      b. 10-25 knots
      c. 25-50 knots
   2) Current
      a. 0-3 knots
      b. 3-5 knots

3) Tide

a. 0-5 ft
b. 5-10 ft
c. 10-15 ft
d. 15-20 ft

4) Varying conditions of wind, current, and tide

E. Various own ship speeds:

1) 0-5 knots
2) 5-10 knots
3) 10-15 knots
4) 15-20 knots

F. Various loading conditions:

1) Light
2) Fully loaded
3) Ballasted

G. Visual details:

1) Day
2) Night
3) Fog

H. Sea states:

1) 0-3
2) 4-5
3) Over 5

I. Weather:

1) Rain
2) Snow
3) Sleet
4) Clear

J. Different ship types (i.e., VLCC, containership, LNG) sizes, characteristics (e.g., turning circles), and tonnages of ships

K. VTS information:

1) Available
2) Not available

L. Vessel proceeding:

1) Inbound
2) Outbound

M. Navigation aids on board will vary

N. Changeability of conditions:

Conditions A through M should be varied during training exercises.

Specific Functional Objectives

The SFO's will be presented in detail in five categories that span the major areas required for the training of ship handling skills. These categories are:

I. Fundamental Ship Handling:

   A) Ship-Environmental Effects
   B) Ship Characteristics
   C) Hydrodynamic Effects
   D) Maneuvering Techniques
   E) Rules of the Road

II. Integrated Ship Handling:

   A) Port Entry
   B) Restricted Waterway/Channel Navigation and Ship Handling
   C) Approach a Single Point Mooring
   D) Approach a Dock
   E) Approach an Anchorage

III. Emergencies

IV. Team Coordination/Communication

V. Bridge Procedures

I. Fundamental Ship Handling

A. Ship-Environmental Effects

Maneuver the vessel, holding course and heading under both steady state and varying environmental conditions:

1. Wind speeds of 0-50 knots (any direction)
2. Current speeds of 0-5 knots (any direction)
3. Sea state of 0-9
4. Any combination of 1 through 3 above.

B. Ship Characteristics

1) Understand the following factors involved in ship maneuvers:

   a. Drift angle
   b. Advance and transfer
   c. Tactical diameter
   d. Diameter of a steady turning circle
   e. Pivoting point
   f. Loss of speed in turn
   g. Angle of heel in turning
   h. Displacement

2) Understand and project response time to the following to make the proper ship control actions:

   a. Rudder response (starboard and port - 5^{o}, 10^{o}, 15^{o}, 20^{o} 25^{o}, 30^{o})
   b. Acceleration, deceleration (use of tables)
   c. Heading change rate and its time dependency
   d. Effect of rpm change on turning characteristics (i.e., increase or decrease in rpm) such as kick effect
   e. Effect of draft
   f. Effect of freeboard

3) Understand and apply the following to ship maneuvering situations:

   a. Maneuvering as a function of ship speed
   b. RPM change time delay, including forward to reverse
   c. RPM change rate over time

4) Understand and apply the effect of the following on stopping distance, time, and position:

   a. Effect of draft
   b. Effect of freeboard
   c. Effect of block coefficient
   d. RPM factors (e.g., engine time to reverse)
   e. Rudder factors (e.g., deceleration in turn)
   f. Deceleration tables

5) Stop the vessel predicting its time dependent path, considering various displacements, speeds, astern rpm, and engine time to

reverse, using each of the following techniques:

a. Rudder cycling
b. Coasting stop
c. Full engine reverse
d. J stopping maneuver
e. Crash stop
f. Other stopping devices such as variable pitch propeller, twin screw, and rotatable propeller

C. Hydrodynamic Effects

1) Compensate for or take advantage of the effect of suction between ships as well as between own ship's quarter and the shallower water at the edge of the fairway when:

a. Maneuvering around docks
b. Maneuvering in confined waters
c. Meeting or passing another vessel in a confined channel

2) Compensate for or take advantage of bank effects when maneuvering through the channel.

D. Maneuver Techniques

1) Execute a zig-zag (Kempf) maneuver, projecting own ship's track:

a. At a speed of 15 KT in the open sea, prior to the maneuver
b. Using no greater than a 20° rudder angle

2) Execute a spiral maneuver, projecting own ships track:

c. At a speed of 15 KT in the open sea, prior to the maneuver
d. Begin by putting over a 15° starboard rudder

3) Execute a Williamson turn to pick up a man overboard in reduced visibility.

4) Maneuver the vessel through the channel under high wind conditions, using the kick effect to assist in maintaining own ship's position within the channel.

5) Plan and carry out when to initiate a turn by determining the amount of rudder, the use of rpm, and other operations (e.g., kick effect) along with the correct timing for implementation.

E. Rules-of-the-Road

1) Detect and interpret ship traffic for required collision avoidance actions when own ship is the stand-on vessel and the following situations exist:

a. Head-on
b. Overtaking
c. Crossing

2) Detect and interpret ship traffic for required collision avoidance actions when own ship is the give-way vessel and the following situation exists:

   a. Head-on
   b. Overtaking
   c. Crossing

3) Sound the appropriate whistle signals in compliance with the regulations specified for the Rules of the Road when:

   a. Maneuvering and using warning signals
   b. Using sound signals in restricted visibility
   c. Sounding distress signals

II. Integrated Ship Handling

A. Port Entry

1. Develop port entry, channel navigation, and docking plan with alternatives. Execute the plan with the necessary alterations.

Navigate the vessel through the waterway plotting own ship's position with data obtained from the following using other methods as necessary:

2. Decca
3. Loran
4. RDF
5. Visual fixes
6. Radar.
7. Navigate through the waterway, operating a depth finder to determine water depth and assist in fixing own ship's position
8. Navigate through the waterway, operating a radar unit to aid in the detection of navigational hazards and aids
9. Maneuver the vessel through the waterway, communicating via ship-to-ship, using the proper VHF frequencies, exhibiting proper terminology and procedures to avoid collisions
10. Communicate with the pilot boat or with tugs for planning purposes when entering the port, exhibiting proper terminology and procedures
11. Communicate via ship-to-shore to determine docking location and have docking preparation initiated
12. Send/receive communication from the pilot as to "what side of the ladder" and weather at the station, using the appropriate terminology and procedures
13. Maneuver the vessel to come to slow and decide whether to turn to right or left for lee to pick up/drop off a pilot
14. Approach the channel, entering the appropriate traffic separation schemes when varying traffic density and various types of ships are present.

B. Restricted Waterway/Channel Navigation and Ship Handling

Maneuver the vessel through the channel when the channel is restricted in width and depth relative to the ship's beam and draft.

1. Maneuver the vessel through port and starboard turns in a channel, changing ships speed as necessary and using a bow thruster when the channel bends are:
   a. Greater than 90^{o}
   b. 60^{o} - 90^{o}
   c. Less than 60^{o}

2. Maneuver the vessel under a bridge structure using appropriate planning techniques (e.g., studying charts and publications). The following bridge conditions should exist:
   a. Satisfactory horizontal and vertical clearance

b. Satisfactory vertical clearance but horizontal clearance is constrained by bridge support structures
c. Bridge is lighted
d. Bridge is unlighted

3. Time the maneuver for the opening of the bridge during different stages of approach when:

   a. Opening time communicated is correct
   b. Opening time communicated is delayed

4. Maneuver the vessel to remain on the intended track, when approaching and maneuvering into:

   a. 2 cross channels
   b. 3 or more cross channels
   c. "Y" channel (junction)

5. Execute a starboard and a port turn into crossing and "Y" channels, projecting own ship's track.

6. Maneuver the vessel through a blind turn (i.e., visual and/or radar detection obstruction) in a channel when:

   a. Other ship contacts are obscured by hills, trees, natural barriers, and manmade structures
   b. Navigational aids are hidden until turn begins
   c. Oncoming vessel creates a meeting situation

7. Maneuver the vessel in the channel and through various turns when forward vision is partially obstructed by ship structure or cargo (e.g., deck load stacking).

8. Conn the vessel through the channel with consideration for the following nearby obstacles located at various positions within the channel:

   a. Dredges
   b. Ships anchored adjacent to, or in the channel
   c. Numerous small craft, sailboats, fishing boats, etc.
   d. Vessels in tow
   e. Buoy tenders
   f. Work under construction
   g. Ship not under command
   h. Cables and pipelines
   i. Breakwater

9. Maneuver the vessel to avoid a shoal or a wreck in the vicinity of the channel entrance when:

   a. Marked by a buoy and/or
   b. Fathometer is inoperative and/or
   c. Possible shoaling due to recent storm

10. Maneuver the vessel through the ice.

11. Maneuver the vessel to avoid navigating through ice.

12. Maneuver the vessel through the channel without deviating from the intended track, when the navigational range structures available for various channel legs have:

    a. A light extinguished
    b. One or both range structures obscured, or
    c. One structure missing.

13. Maneuver the vessel through the channel when the navigational aids available for various legs of the channel are:

    a. Extinguished
    b. Off position
    c. Missing

14. Maneuver the vessel through the channel when natural fixed or navigational structures are:

    a. Masked
    b. Missing

15. Maneuver the vessel into/out of the channel when a ship is anchored in the approach to the sea buoy and the radar reference sea buoy is off location.

16. Communicate via ship-to-tugs using appropriate format and terminology to request tug assistance for channel maneuvering.

17. Coordinate strategy to be used by tugs. Then communicate with the tugs as to the number of tugs needed and the placement of each.

18. Coordinate the activities and maintain communication with the pilot and mate.

19. Configure the vessel to facilitate tug assistance (e.g., ship speed). Coordinate vessel actions (e.g., rudder, rpm) with tug efforts to achieve objectives for normal situations.

C. Approach a Single Point Mooring

1. Determine the approach bearings and the points at which to reduce speed and/or stop engines.

2. Maneuver the vessel in the approach to the mooring coordinating approach bearings and speeds, safely avoiding other traffic and other moored vessels.

D. Approach a Dock

1. Determine the approach bearings and the points at which to reduce speed and/or stop engines, with tug assistance.

2. Maneuver the vessel, with tug assistance, in the approach to the dock coordinating approach bearings and speeds, safely avoiding other ship traffic.

E. Approach an Anchorage

1. Select the appropriate courses and navigational aids to fix the ship's position en route to the appropriate anchorage, check the depth of the water at the anchorage, and locate the turning bearing.

2. Maneuver the vessel to approach the anchorage position, taking into account the location of other anchored vessels. Accomplish this maneuver under the previously determined conditions as well as under the following conditions:

   a. Water depths of 100-500'
   b. Various types of holding ground
   c. One anchor/two anchors
   d. Having way on/having no way on
   e. Using remote sensors and pilot house control

3. Anchor the vessel. Once anchored, take cross bearings to fix position.

III. Emergencies

For emergency situations, the following conditions should be addressed in addition to the previously denoted conditions:

a. Varying duration of failure
b. Ship configuration

    1) Twin screw
    2) Single screw
    3) Controllable pitch propeller

c. Various time lags for power response

1) Plan for emergency action alternatives prior to entering the harbor, based on the identification of relevant harbor characteristics. Carry out plans under the various harbor situations.

2) Anchor or ground the vessel clear of the channel to minimize casualty damage due to:

    a. Loss of power
    b. Loss of steering
    c. Collision
    d. Fire

3) Maneuver the vessel through the channel maintaining ship control as best as possible when each of the following types of rudder failures occur:

    a. Loose rudder
    b. Rudder jamming of mechanical systems
    c. Partial loss of rudder

4) Safely maneuver the vessel when there is a degradation in the amount of power available, including complete power failure.

5) Maneuver the vessel through the channel when an electrical failure affecting ship control occurs in the following equipment:

    a. Rudder angle indicator
    b. Radar (poor visibility)
    c. Gyro
    d. Engine order telegraph

6) Use tug assistance when a casualty (e.g., power and/or steering failure) occurs while underway to:

    a. Moor or dock
    b. Anchor
    c. Otherwise assist in maintaining vessel safety

7) Detect, correct and/or compensate for the following ship control errors caused by ship's personnel and/or pilot:

    a. Wrong command ordered on the EOT
    b. Wrong command implemented by engine room
    c. Helm put over the opposite way from that which was ordered
    d. Helm put over by an improper amount
    e. Depth sounding reported incorrectly
    f. Position plotted incorrectly
    g. Contact's course, speed, range, or CPA plotted and/or reported incorrectly

8) Maneuver the vessel through the channel when each of the following types of communication are required by are inoperative:

   a. VHF
   b. Whistle
   c. Running lights
   d. Walkie-talkies
   e. Internal phone systems

9) Maneuver the vessel avoiding any collisions when the following equipment are inoperative:

   a. Radar
   b. CAS

10) Configure the vessel to facilitate tug assistance (e.g., ship speed). Coordinate vessel actions (e.g., rudder, rpm) with tug efforts to achieve objectives for emergency situations.

11) Maneuver the vessel through turns in the channel when:

   a. Rudder failure occurs
   b. Engine failure occurs

IV. Team Coordination/Communication

1) Within the framework of set procedures which are situation dependent, each team member should perform parallel and serial functions in coordination with the other team members and in a timely manner.

2) Within the framework of set procedures which are situation dependent, each team member should transmit the required information to the appropriate source in a clear, concise, and timely manner, using the proper format and terminology.

V. Bridge Procedures

1) Research tidal information, check charted characteristics of navigation lights and buoys against lists of lights and navigation bulletins, consider the ship's maneuvering characteristics, and check prevailing conditions; then organize port entry/port exit passage plans (preferred and alternate tracks) in detail so as to provide for full control of navigation. Organize the duties and pattern of communications of a bridge team so that the plan, once made will be executed properly especially when the unexpected arises. Include alternative action contingencies for the development of unexpected situations.

2) Execute the plans during passages, incorporating alternatives as required.

APPENDIX B

LICENSING ISSUES

B.1 INTRODUCTION

B.1.1 Background of Licensing Issues

Throughout the history of the maritime industry in the United States, technological advancements have changed navigation and shiphandling procedures, while concomitantly posing potential safety problems. For example, with the advent of the steamship there was a corresponding increase in loss of life and property due to boiler explosion and fires. As a result of these disasters, preventive measures were taken to ensure the safety of lives and property aboard ship.

Prior to 1942, the Bureau of Marine Inspection and Navigation was responsible for examining and licensing marine personnel. In the hope that more knowledgeable personnel would improve marine safety, this agency used written essay examinations to determine the competency and qualifications of maritime personnel.

Since 1942, the United States Coast Guard has been responsible for examining and certifying licensed seamen. The USCG, during its early years of involvement in the licensing process, used the examinations of its predecessor as the standard by which to issue, deny, or upgrade a mariner's license. (See Wohlfarth, 1978). Dissatisfaction with the examination increased over the years due to increasing obsolescence of its content. By 1960, some progress had been made in culling out those questions which were nonapplicable to (then) contemporary methods of navigation and shiphandling. Several new subject areas were also incorporated. Further, subjective scoring of essay examinations was gradually being replaced by objective multiple-choice questions.

In 1969 the Coast Guard contracted the Educational Testing Service (ETS) to research all aspects of the merchant marine licensing program. As a result of the ETS research, the present licensing examination consists totally of objective multiple-choice questions. Standards of knowledge required for licensing have been established and are monitored by statistical analysis for validity and reliability. All examination procedures have been standardized, including scoring, sequencing of subject areas, and time constraints allowed for initial and retake examinations.

B.1.2 Present Licensing Issues

Technological advancements continue to impact ship safety. The growing need for energy-producing products has increased the demand for shipment of large quantities of bulk ore, oil, and liquefied gases and consequently the size of ships used to transport this cargo. The dramatic increases in the size of ships and in the amount of hazardous cargo transported have again produced new and challenging problems for the marine industry. With the increase in the size of ships, waterways which at one time were considered adequate in depth and width for safe vessel transit, now require greater knowledge of and experience in shiphandling. The effects of shallow water, which were not an extreme consideration when maneuvering the smaller product carriers in wide, deep channels of 20 years past, had significantly impacted the control of today's larger vessels in these same channels. Compounding the situation, the absorption of shiphandling skills is not a prerequisite for promotion, since promotion is based upon examination. Much of the

knowledge and experience necessary for shiphandling is not found in textbooks from which examination questions are drawn (Plummer, 1945). Predictions of future officer shortages also indicate the probability of rapid promotion and consequently of less experienced officers in command (Rencil, 1978).

With the increase in ship size and potential for disaster involving large volume energy transportation, a new dimension in shiphandling skill has evolved. The margin of error in conning large vessels in restricted waters has been reduced, requiring the mariner to process information more accurately and to make fine perceptual and cognitive decisions more rapidly. For example, the processing of information demands an enhancement in accuracy of:

- Spacial orientation and positive locations
- Simultaneous or rapid successive comparisons of information input
- Fine quantitative discriminations
- Quick selection of information from a large number of alternatives
- Rapid referability (scanning, searching)
- Transmitting difficult material
- Rapid two-way communication
- Retention of meaningful material
- Perception of slow rates of turn
- Perception of changes in velocity relative to acceleration and deceleration

The problem concerns the capability of the mariner to process information as a function of the increased information presently available on modern vessels and the manner in which the information is distributed over time and space (Howel and Briggs, 1959).

The present deck officer licensing structure does not address problems that have emerged with the development of large ships with unusual handling characteristics but covers a wide variety of other concepts such as:

- Whether the vessel is inspected or uninspected
- Vessel tonnage
- Particular waters in which the vessel operates
- Propulsion system (steam, diesel, sail)
- Horsepower rating
- Industry or type of activity in which the vessel is engaged

Licensing requirements should be re-examined to assess skills required for present day shiphandling. This would greatly reduce the casualties resulting from the unusual handling characteristics of today's larger vessels and from the handling of unstable cargo. As a result of the variety of licensing concepts constituting the present-day structure, there is an inordinate number of deck officer licensing categories: 35 different master's licenses, 22 different mate's licenses, and 13 different federal pilot's licenses (DOT publication CG-191, 1976).

B.2 LICENSING ISSUE PROBLEMS

The following excerpts from Shimberg (1969) illustrate some problems of the present licensing structures.

> "The breakdown on horsepower is meaningless. It would be better to endorse applicants by type of propulsion system . . .
>
> "For the deck officers, retain the concept of waters, but not the concept of Inspected/Uninspected. The latter is meaningless for licensing purposes . .
>
> "The Coast Guard should divorce the examination from the concept of tonnage. They are not correlated. <u>Anyone</u> who is going to run a boat needs the rudiments of navigation, Rules of the Road, Shiphandling and Docking. These are the topics which should be included regardless of Tonnage.
>
> "First we must identify just what we are trying to accomplish in any licensing program. In its simplest form, I submit we are trying to license persons who <u>demonstrate</u> competence as navigators or engineers."

A weakness of the present licensing structure is that shiphandling competence is determined solely by a written examination. There appears to be no clear relationship between the examination content and the ability to carry out the duties of a competent deck officer. To establish such a relationship, a demonstration of proficiency is required. For example, graduation from a maritime academy may ensure that the appropriate knowledge requirements for becoming a deck officer have been met; however, the implementation and demonstration of shiphandling skills is not adequately supplied by such institutions. Under the present licensing program, once an individual has obtained a license he must renew it within 5 years. License renewal, however, does not require the individual to sail within that 5-year period. Consequently, a deck officer may indefinitely renew his license in the absence of any sea time requirement.

Given the present licensing structure and the problems accompanying contemporary shiphandling, demonstration of shiphandling skills is necessary to improve safety at sea and economy of shipping. Demonstration of proficiency implies development of a proficiency training program for which the role of the company, the union, and government agencies has been identified. These groups would provide standards and criteria which must be met by a viable training program for the demonstration of shiphandling.

B.3 UPGRADING THE PRESENT LICENSING PROGRAM

In response to the international protest over increasing shipping disasters, the Inter-governmental Maritime Consultative Organization (IMCO) has established an international convention to investigate Standards of Training Certification and Watchkeeping for Seafarers. This organization is responsible for establishing minimum requirements for certifying the competency of licensed deck and engine personnel. As a result of the conference, various subcommittees will review suggestions for upgrading standards of watchkeeping supplied by government and nongovernment organizations.

Establishing specific minimum standards of watchkeeping in terms of knowledge and skills will benefit the safety of the crew, cost of operations, and preservation of natural

ecological balance. For a summary of the recent international conference (i.e., 14 June to 4 July 1978) on standards of training, certification and watchkeeping for seafarers, see Exhibit B-2.

B.4 CURRENT LICENSING PRACTICES

The rules and regulations prescribed by the USCG illustrate the structure of current licensing practices for ordinary seamen through master/pilot (DOT publication CG-191, 1976). In general, some basic requirements must be met by all seamen prior to employment aboard any U.S. flag merchant vessel. These include proof of citizenship and evidence of good health, satisfactory character, and the minimum level of experience. Role requirements of the educational institutions in the overall, current licensing practices are also included. See Exhibit B-3 for specific requirements.

Under the existing system, re-examination must take place within 1 month from date of last failure. In case of another failure, applicant must wait 3 months. If refused for a second time the applicant must wait 1 year from date of refusal before he is allowed to retake the examination.

Requirements for the advancement of licenses are:

> "An applicant for an original merchant mariners document endorsed for service in rating for which no professional examination is required shall produce satisfactory proof that he has a commitment of employment as a member of the crew of a United States merchant vessel.
>
> "A transcript of sea service in the U.S. Navy, U.S. Coast Guard, U.S. Military Sea Transportation Service, or U.S. Army Transportation Corps shall be accepted in lieu of a letter of commitment."

The current licensing structure has several deficiencies. Examinations assess minimum knowledge requirements, however, the relevance of such requirements has not been assessed regarding the ability of the individual to translate such knowledge into the skills and tasks which the deck officer must perform during his watchstanding duties. Furthermore, individuals who pass these examinations are allowed to sail on ships on which they may not be capable of handling under situations which may develop as a result of emergencies, close water, or adverse weather conditions. In short, there are no minimum standards of proficiency aside from knowledge requirements which have been established such that the skills and abilities of shiphandling can be assessed. For example, demonstration of proficiency is not required for fundamental tasks such as radar observers and operators; radar observers are required to pass a written examination as proof of correct operation and use of marine radar equipment. The major flaw in the present licensing practices is the complete lack of any demonstration of proficiency, as well as the absence of a valid set of training criteria which would promote the acquisition of fundamental shiphandling skills and abilities.

B.5 LICENSING ISSUES ADDRESSED TO MARITIME CONSTITUENTS

As discussed in section B.1.2, there are currently 35 different master's licenses, 22 different mate's licenses, and 13 different pilot's licenses. The licensing categories are based on these concepts:

- Whether the vessel is inspected or uninspected
- Vessel tonnage
- Particular waters in which the vessel operates
- Propulsion system (steam, diesel, sail)
- Horsepower rating
- Industry or type of activity in which the vessel is engaged

These fundamental concepts are being challenged in their effectiveness in allowing for the optimal discrimination between skills and abilities necessary to handle varying types of vessels. A long term research program should be established to validate a breakdown of licensing categories on the effectiveness of fundamental concepts which are assumed to make such optimal distinctions. It is suggested that a distinction between licensing categories be related to fundamental skill and ability requirements which vary as a result of:

- The water in which the vessel operates (i.e., close waters, coastwise and open sea)
- The type of propulsion system (i.e., steam, diesel, single or twin screw)
- The type of industry or class of cargo being handled
- The handling characteristics of the vessel

By using these concepts for designating licensing categories, more emphasis will be placed on skills required for handling different types of vessels in different waters. This conceptual framework not only emphasizes the importance of handling characteristics of vessels (both in shallow and deep waters), but requires specific levels of skill and abilities by the mariner in maneuvering vessels of different industries in various waterways. It has been empirically demonstrated that differing psychological strategies for obtaining information regarding the behavior of a vessel are correlated with the handling characteristics of the vessel. As a result of these findings (which will be discussed at length in the following sections of this report), it is obvious that many psychological factors which relate to specific perceptual and cognitive skills are of paramount importance in determining abilities of the mariner to maneuver vessels. To date, however, the current licensing structure does not consider such human factors.

Casualty statistics for collisions and groundings (Cordell and Nutter, 1976) indicate that a distinction between master and pilot duties must occur because an over-reliance on the pilot accounts for a considerable proportion of casualties. The local knowledge and shiphandling skills which pilots have developed over years of experience is necessary for the safe conduct of vessels in restricted or close waters. To meet the objective of increased safety at sea, the master could be required to demonstrate proficiency in shiphandling skills similar to those skills required for pilotage. If minimum acceptable standards of shiphandling in restricted or close waters are required of masters, the over-reliance of the master or the pilot in an emergency situation may be reduced. Given an emergency situation when the master is more apt to know the limitations and capabilities

of his own ship, it would be advantageous for the master to take confident command being familiar with shiphandling in the pilotage waters. Such a distinction of duties would reduce pilot and master uncertainty in assessing a solution to problems.

In many geographic locations, the administration (federal or owner/operator) requires that masters qualify for pilotage. A statistical comparison of casualties between masters having pilotage and masters not having pilotage can assess the frequency of casualties.

Although licenses are not issued as a function of the mariner's knowledge of his employers marine management policy, operations management is a critical issue. For example, if a master is faced with an emergency condition which may involve salvage fees, it is mandatory that the master know the policy of the company's marine division. If salvage policies are uncertain, the master may be reluctant to make necessary decisions concerning the state of his vessel, consuming valuable time which could result in disaster. Such a situation has recently arisen with the stranding of the Amoco Cadez.

Other management issues concerning manpower and crew assignments may also effect the adequacy with which the ship is maintained, as well as the incidence of injury onboard ship. Although different marine administrations have differing management policies, the maritime constituent should note the impact of such procedures in managing the ship and crew.

Another important issue is the working cycle of licensed deck officers. Long periods of isolation and long hours of work involving rapid peaks in stress are not uncommon while serving at sea. These human conditions are known to greatly effect the proficiency of decision-making and other intellectual and physical demands placed upon the individual.

Furthermore, with the relative long intervals of time between sea duty and land-based activities, a proficiency check of the officer's ability to safely manage his vessel would seem reasonable. Such a check can be made prior to taking command after a long leave on shore or during extended periods of at-sea duty.

These issues should serve to form a basis on which re-evaluation of current licensing procedures can be appraised. In general, a particularly prominent resolution of these issues can be accomplished through an investigation of training techniques and training objectives. However, the current federal administration governing the safety in U.S. waterways has not adopted standards of training along with present licensing practices. The burden of the development of standards of training for deck officers has been taken on voluntarily by private industry and the varying labor organizations. Acceptable criteria for training do not exist. Consequently, in the absence of any mandate requiring training, many shipping companies who cannot bear the cost of training have chosen not to institute any form of training in shiphandling skills. Other companies which have sponsored their own particular brand of training have been faced with the problem of losing trained deck officers to other companies which have made no training commitments. Additionally, those training programs designed by individual companies may prove to be ineffective and invalid, since the maritime community has not expended efforts to investigate and evaluate those to-be-trained skills which are necessary for the establishment of valid training standards and criteria.

B.6 TRAINING PROGRAMS LAUNCHED BY INDEPENDENT COMPANIES

Many large shipping companies design training programs to meet the needs of their industry. A brief description of certain training programs undertaken by independent companies provides a representative sample of their training needs.

B.6.1 EXXON Corporation

The Marine Research and Training Center at Port Revel, France is the result of a study determining additional training required by seagoing officer personnel to grow and progress with the shipping industry. The training center is situated on an 8 acre lake designed to include scale model piers, multibuoy seaberths, a single point mooring buoy, and some typical shipping channels. Training takes place on 1/25th scale models of 17,000, 38,000, 190,000, and 250,000 dwt tankers and a 35,000 displacement ton LNG carrier. Instruments on each scale model ship show propeller revolutions, rudder position, heading, and wind speed. All temporal shiphandling events occur in 1/5 of the time which would be required for full scale operations. Wind, wave, and current conditions can be simulated on the lake, and maneuvers can be undertaken during daylight and night conditions. The objectives of this program are to:

a. Provide effective and rapid transition by masters from vessels less than 50,000 dwt to those tanker vessels greater than 50,000 dwt.

b. Provide for the exchange of knowledge and skills between masters and pilots.

c. Provide a situation in which seagoing personnel can test new methods of shiphandling.

d. Improve performance of shiphandling fundamentals (i.e., skills and abilities) and provide an environment for practicing these fundamentals.

B.6.2 P. and O. Bulk Shipping Limited

Beginning in 1967, P. and O. Bulk Shipping Limited conducted an independent investigation of their onboard safety practices. By expanding upon the established United Kingdom standards, they developed a marketable onboard training program. The program consists of:

a. Detailed tanker and gas ship safety information

b. Operating theory audio-visual programs

c. Instituting basic LNG handling techniques onboard ship

d. Repairing gyro, radar, and other navigational instruments

The program success is obvious since shore assistance is rarely needed. The program is continuing to expand, and shiphandling simulators have recently been developed. Requirements for manning have been defined as:

a. Masters must have 3 years experience on one ship before transferring to another ship.

b. Mates and masters new on ships must sail on overlapping periods before they command the ship.

c. Rest periods are also scheduled such that mental stress and fatigue are reduced before the master is allowed to assume the full responsibilities of his command.

d. Master must attend specialized management courses that identify specific company marine management division problems (Marchant, 1978).

B.6.3 Shell International Marine Limited

Shell International Marine Limited has developed a three-step process that trains officers to efficiently solve shiphandling problems (Butt, 1978). First, masters are placed on ships as nautical superintendents who supply guidance for the bridge team and seek out shiphandling problems that warrant deck officers' attention.

Second, specially equipped scaled-down vessels are available at Fleetwood, England to provide practice in navigational tasks requiring precise decisions and planning. The consequences of inadequate planning, can be emphasized by creating the conditions of an accident. Exercises are analyzed with resultant discussions to determine errors.

Third, new shiphandling simulators have been used to further develop bridge team training courses and shiphandling skills.

B.6.4 Chevron Shipping Company

The Chevron Shipping Company believes that serious casualties can be minimized by maintaining "good watch organization and taught bridge discipline" (Leland, 1978). They established a standard bridge organization consisting of a 5-day, live-in shore training program, and a shipboard training program which emphasizes watch organization and bridge control. Several bridge watch systems were designed to clearly define all duties" so that disciplined and coordinated action can be taken to obtain and evaluate all available information and to keep the conning officer advised of the navigation situation." Some navigational procedures that the company has defined in detail are:

- Watch officers responsibility
- Bridge equipment familiarity
- Night and standing order
- Calls to the master
- Watch preparations relief
- Watch relief
- Watch surrender
- Lookout
- Helmsman
- Course changes
- Sea lanes and traffic separation schemes
- VHF radio communications
- Low visibility procedures

- Radar/collision avoidance system use
- Full use of navigational equipment
- Celestial fixes requirement
- Visual bearings use
- Compass accuracy verification
- Anchoring procedures
- Tests and inspections
- Record keeping
- Engine room calls
- Pilot

These training programs demonstrate that safe, efficient shiphandling results from extensive training. The majority of company administrations, however, have not established training standards. Therefore, the skills acquired by a well-trained watch officer may be useless if the skills of officers manning other vessels in an interactive situation are substandard. National and international training standards in watchkeeping must be established for the maritime industry.

B.7 INTERNATIONAL CLIMATE

Internationally, government agencies have been responsive to a system of minimum standards of training and watchkeeping as illustrated by the wide acceptance of the Inter-Governmental Maritime Consultative Organization (IMCO). IMCO has established regulations requiring masters and officers of all disciplines to demonstrate continued proficiency by updating their knowledge of shiphandling and shipping technology. Further regulations will require that refresher courses and re-examination procedures be made mandatory for officers who have not sailed during the licensing period.

However, in addition to regulations established by IMCO, many nations have set specific training requirements for the licensing of deck officers and pilots.

For example, the United Kingdom Department of Trade has recently set requirements to train personnel sailing on specialized ships including tankers, chemical carriers, and liquefied gas carriers. To become an officer in the merchant fleet, the applicant must first complete a comprehensive sea service and college training program covering a 3-1/2 year period. After serving a minimum of 24 months at sea, he then may sit for a second mate's license.

When the applicant has met all training requirements and has passed the second mate's examination, he returns to sea as a third mate for 12 months before he is eligible to sit for his first mate's license. Given 42 months following receipt of his second mate's certificate and not less than 24 months sea service since obtaining his first mate's license, he is then eligible to sit for his master's license. With normal progress through the system, the individual could obtain his master's license after his 26th birthday.

In addition to obtaining these licenses, there are statutory training programs which the applicant must complete. These training programs provide "Efficient Deck Hand", "Lifeboat", "Radar Observers", and "Fire Fighting" licenses. Prior to obtaining his

master's license, the applicant must also take courses on a radar simulator and in advanced medicine. Steps have also been taken by the Department of Trade to completely revise the entire certification structure of the United Kingdom Merchant Navy in an effort to increase the competency of deck and engine officers (Safety at Sea International, August 1977).

The Netherlands government is responsible for training pilots since they are government employees. Upon completion of an 8-week basic education training course, apprentice pilots are assigned to local districts and are required to make a fixed number of pilot trips under the supervision of a qualified pilot. All pilots must take part in a few terms of probation on harbor tugs and in the vessel traffic service. Following his appointment, the pilot begins his career on limited tonnage. Advancement to unlimited tonnage takes approximately 7 years.

The Dutch government experimentally used simulators for shiphandling training to determine if VLCC experienced pilots could learn additional shiphandling skills and if future VLCC pilots could get effective basic training on the simulator. The shiphandling simulator is now a common method of training VLCC pilots. The Netherlands government believes that pilots with basic training on the shiphandling simulator are better prepared for their jobs (Valk, 1978).

B.8 SIMULATOR USE FOR DEMONSTRATION OF PROFICIENCY IN LICENSING

Shiphandling simulation should be evaluated to determine its application to licensing and training. In this context it is difficult to separate training issues from licensing requirements because if mandatory minimum training standards are established by the USCG as a result of the IMCO convention, the licensing of deck officers would be contingent upon meeting these specified minimum training standards. Standards and criterion may be established for watchstanding performance, but the training techniques and apparatus used for implementing the training program would not be specified by IMCO. The responsibility of specifying training procedures would be determined by the training agency, MarAd, and the licensing and certification agency, the USCG.

The shiphandling simulators have been successfully used as a training tool throughout Europe and the United States. Furthermore, the capability of simulation to place the deck officer in emergency conditions restricting maneuverability, which would otherwise be impractical from a safety and economic standpoint, lends itself as the only realistic alternative for training. The shiphandling simulator can also be used as a diagnostic tool to determine competency of deck officers.

As the standards of training and watchkeeping evolve, effective training programs must be established to ensure the retention of high proficiency performance. Retention of these skills, which have been enhanced through training, is a key issue in the development of standards of training. It is necessary that highly proficient performance developed during training be maintained over lengthy intervals of time at sea while on-the-job.

B.9 INVESTIGATION OF SKILLS AND ABILITIES WHICH WOULD REQUIRE NEW LICENSING CRITERIA

IMCO identified the need for specialized training of deck officers for handling ships with unusual maneuvering characteristics to improve safety at sea. There are psychological limitations in handling ships of differing maneuvering characteristics. For example, important aspects of shiphandling include:

- Perception time of velocities and acceleration/deceleration of the ship
- Ability to predict temporal events given the delays of ship reactivity to rpm and rudder changes
- Capability to perceive motion components due to wind, current, and vessel characteristics
- Perception of rate of turn of own ship and change in aspect of other vessels
- Ability to imagine own ship's orientation relative to other vessels in the absence of background cues

Little is known about the human's limitation of these psychological factors. It has been demonstrated however, that the human has a very limited capacity to perceive very slow motions such as a docking maneuver. For example, the smallest yaw velocity which can be perceived is about 1 minute of arc per second (Wagenaar, 1978). To perceive a change in velocity of yaw motion, the velocity must be doubled or halved within five seconds (Hick and Bates, 1950) and the change must be instantaneous rather than gradual. Negative acceleration, however, has been found to be more accurately perceived than positive acceleration (Gottsanker, Frick, and Lockard, 1961).

Other studies using a full scale ship maneuvering simulator have shown that tankers about 100,000 dwt move so slowly that the human cannot perceive changes in acceleration and deceleration. Consequently, externally important information is missing that could effect the correct execution of a maneuver. Differing modes of operation which helmsman use to steer vessels have also been correlated with the size of the vessel (Sato, Takagi, and Takagi, 1977). Investigations have shown that helmsmen having experience steering small ships (i.e., 30,000 dwt) steer a larger vessel (i.e., 350,000 dwt) by using the compass to determine yaw rate. However, those with experience in steering large vessels of 200,000 dwt, steer the 350,000 dwt tanker by using the rate of turn indicator. Helmsman with experience steering smaller ships have difficulty in steering a larger vessel which requires a large check helm and shows a slower reaction to steering.

Other studies conducted by the Institute of Perception (TNO) indicate that the inertia of large ships causes serious psychological problems involving temporal events. For example, the time lag between a rudder command and the reaction of the ship is 15 seconds or more. Research has indicated that the human has difficulty in track keeping when the time lag between command and reaction is greater than 4 seconds, which is well under the 15 second lag of large tanker vessels. Other temporal problems involving the inertia of large vessels are associated with the human's ability to anticipate the result of a maneuver. With the long time lags in reactivity of these large tankers, the problem of predicting the position of the ship several minutes in advance becomes a difficult task. Complex issues involving the perception of wind, current, and bottom effects on the vessel must also be dealt with to determine cues which can be made available to the human for correct, adequate action to be taken. With the present state-of-the-art navigation equipment, it is difficult for the captain or pilot to determine if a change in position is

due to errors in the equipment, drift due to current, or set due to wind. The unique skills of the master and pilot are made more complex by the inertia and slow, gradual motion of these larger vessels. Shiphandling can be improved by supplying information to the human which would otherwise be missed.

The demand for specialized training for the operation of vessels of unusual maneuvering characteristics must take the above human limitations into consideration. Such training would initially require research to determine those human limitations encountered when maneuvering large ships in restricted waters. The need for specification of specialized shiphandling skills determined through research would uncover those components of shiphandling which are in need of particular types of training to close the gap of human limitation. Other by-products of such a training research program would produce standards for the development of improved navigation equipment capable of overcoming human limitations.

Another solution to offset psychological limitations and their effect on shiphandling is to identify those abilities which correlate highly with the correct execution of ship maneuvers. A distinction, however, must first be made between the concept of skill and that of ability.

An ability is a "broad capacity underlying performance in a complex skill or skills and related to performance in a variety of human tasks" (Fleishman, 1972). A skill defines the level of proficiency on a particular task and can be made up of several component abilities. By identifying the abilities which comprise shiphandling skills, training techniques can be developed to improve skill performance. Ability training can be accomplished by using a low degree of simulator fidelity as training abilities have produced positive transfers to a variety of transfer tasks (Hogan,1978). Low level fidelity of simulation can produce positive transfer of abilities and consequently the cost of training equipment can be reduced. Furthermore, since ability training is nonspecific, it would allow for increased flexibility of personnel, since personnel would be capable of transferring their abilities to a broad range of tasks. Also, since training applies to a broad range of tasks, training in specific skills would also be reduced.

B.10 DEMAND FOR SIMULATOR USE IN TRAINING/LICENSING

The requirement for specialized training of masters who will command vessels with unusual maneuvering characteristics will produce a demand for cost effective training programs. The acquisition of necessary skills and abilities to meet the IMCO objectives for standards of training and watchkeeping can be cost effectively provided by a shiphandling simulator. Many European governments and United States operators are using simulation to upgrade pilot and master proficiency in executing maneuvers in restricted waters. This type of simulation training has been found most cost effective. Due to the staggering costs of actual ship operations, onboard training would be prohibitive. The cost effectiveness of simulator training has resulted in the construction of various types of shiphandling simulators throughout Europe, Japan, and the United States. At present, these simulators are in full time use as training and/or research tools. The adoption of training standards and the demonstration of proficiency in shiphandling as a requirement for the issuance of a deck officer's license would produce an increased demand for shiphandling simulators.

To assess the future demand for the use of shiphandling simulators for licensing, statistics on the number of master's licenses issued and renewed per year from 1951 to 1977 were compiled from the Proceedings of the Merchant Marine Safety Council and are presented

in TABLES B-10-1 and B-10-2. Data covering years 1953, 1954, and 1965 were unavailable and not included in this analysis. From this data, trend analyses were conducted to predict future licensing demands. FIGURES B-10-1 and B-10-2 present this data in graphic form along with the linear best fitting line which describes the data trend. From the least squares analysis conducted on the data, there is an increasing trend for the number of original master's licenses issued. This increasing trend is slight, equaling the addition of only two new original master's licenses per year to the mean of 231 original master's licenses per year.

The least squares analysis of the number of master's licenses renewed each year indicates a considerable decreasing trend. Given the mean value of 1,624 renewed master's licenses each year, the analysis revealed that a decrease of approximately 40 renewals each year will occur if the past trend of the data remains invariant. In total, approximately 1,855 master's licenses are issued each year and this figure is decreasing by approximately 38 licenses per year. Nevertheless, the demand to process this number of masters, given a training requirement for licensing, would create a considerable workload for USCG and MarAd personnel.

B.11 SIMULATION LOCATION IN THE UNITED STATES

A mandated training program for licensing maritime officers would increase construction of training simulators. Access to the training centers could be determined by the location of those USCG examination centers which have the highest applicant volume for deck licenses. Presently there are 47 USCG marine inspection offices located throughout the United States, and three offices located outside of the United States in Rotterdam, Manila, and Singapore (DOT publication CG-268, 1977). Equipping each of these inspection centers with shiphandling simulators would not be cost effective. However, if a modular training program is endorsed as a result of empirical investigations conducted by the USCG and MarAd, many of the inspection centers could incorporate certain training modules with less sophisticated training devices. A few full scale bridge simulators could be strategically located within the United States to train whole task shiphandling skills. As an alternative, privately owned and operated ship maneuvering simulators, presently operational within the United States could be endorsed and contracted by the USCG and MarAd to be used for shiphandling training. This would create an increased market for development and construction of shiphandling simulators and would reduce the manpower and maintenance requirements which would otherwise burden the USCG and MarAd. Costs of these shiphandling training programs could be partially subsidized by the Department of Transportation/USCG, the Department of Commerce/MarAd, and state governments/unions which are presently subsidizing maritime training academies.

B.12 INTERNATIONAL IMPLICATIONS

Internationally, government agencies have been responsive to establishing minimum standards of training and watchkeeping as demonstrated by the recent IMCO conference. This conference attracted the largest number of delegates from over 70 member nations and was marked by high agreement indicating that speedy, effective, codification of minimum required standards may be attained. IMCO goals which have international implications are to:

- Provide financial assistance for nations having limited financial and technical resources

TABLE B-10-1. NUMBER OF ORIGINAL MASTER'S LICENSES ISSUED

YEAR	NUMBER
1951	283
1952	350
1955	173
1956	241
1957	268
1958	221
1959	152
1960	156
1961	127
1962	152
1963	163
1964	152
1966	187
1967	258
1968	239
1969	332
1970	239
1971	206
1972	215
1973	234
1974	327
1975	301
1976	356
1977	214

$\underline{E} = 5546$

$\overline{X} = 231.09$

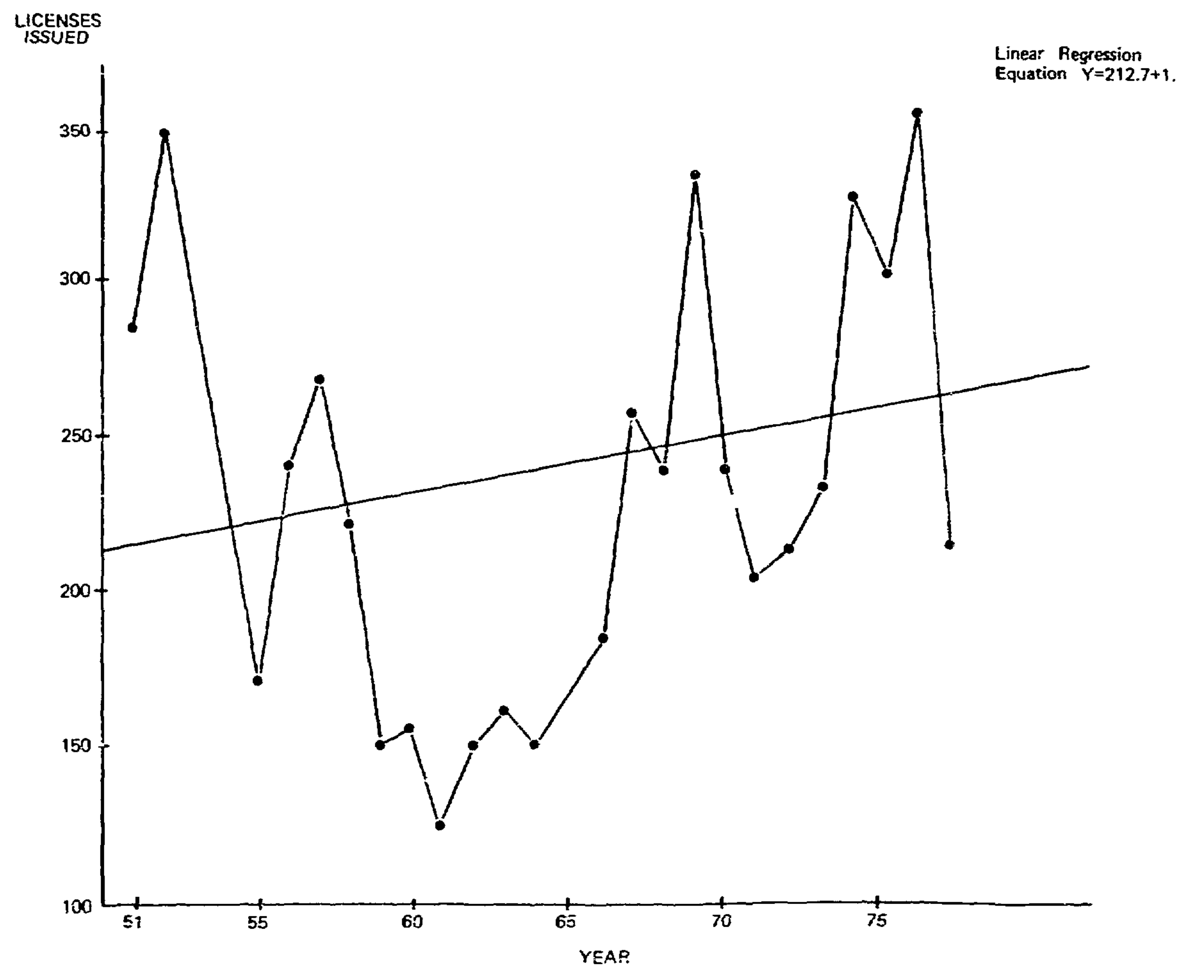

Figure B-10#1. Linear Trend of Original Master's Licenses Issued

TABLE B-10-2. NUMBER OF RENEWED MASTER'S LICENSES ISSUED

YEAR	NUMBER
1951	1989
1952	1909
1955	1857
1956	2177
1957	2555
1958	2142
1959	2036
1960	1529
1961	1604
1962	1748
1963	1713
1964	1727
1966	1404
1967	1565
1968	1540
1969	1471
1970	1214
1971	1257
1972	1516
1973	1147
1974	1270
1975	1109
1976	1288
1977	1221
	E = 38988
	$\bar{X}$ = 1624.5

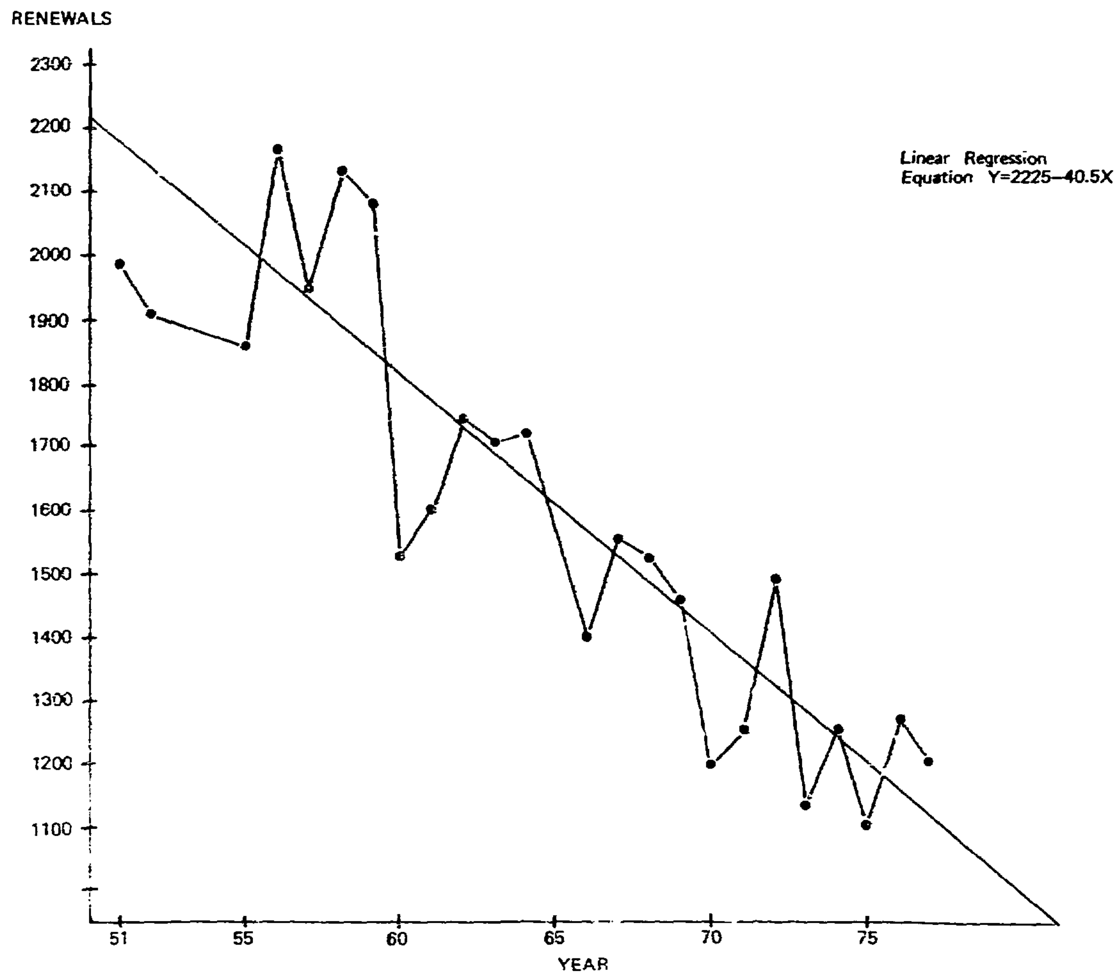

Figure B-10-2. Linear Trend of Renewed Master's Licenses Issued

- Ensure continued monitoring and upgrading of knowledge and shiphandling proficiency for masters and deck officers
- Regulate renewal of licenses by requiring applicants who have not been at sea for extended periods of time to take a refresher training and re-examination before obtaining a renewed license

The outcome of these IMCO resolutions should increase proficiency in shiphandling.

B.13 CONCLUSIONS AND RECOMMENDATIONS

1. Specific demonstration of proficiency in shiphandling should be a requirement for licensing.
2. Specialized training for deck officers in handling vessels with unusual maneuvering characteristics should be required to improve safety at sea.
3. There is no clear relationship between present examination content and the ability to carry out duties as a competent deck officer.
4. Demonstration of proficiency and establishment of minimum requirements of training are crucial to the certification of deck officers.
5. Human skills and abilities required for shiphandling are not considered within the present licensing categories.

B.14 RESEARCH ISSUES

1. Determine the psychological factors relating to specific perceptual and cognitive skills that impact the ability of the mariner to maneuver vessels.
2. Determine the psychological limitations of these psychological factors.
3. Validate the current breakdown of licensing categories.
4. Identify those abilities which correlate highly with the execution of ship maneuvers.
5. Assess the skills and abilities required for present day shiphandling and make recommendations to modify present licensing requirements.
6. Investigate and evaluate those to-be-trained skills which are necessary for the establishment of valid training standards and criteria.
7. Determine the role of simulation in the licensing and examination program.

EXHIBIT B-1

INTERNATIONAL CONFERENCE ON TRAINING AND CERTIFICATION OF SEAFARERS

RESOLUTION 17

ADDITIONAL TRAINING FOR MASTERS AND CHIEF MATES OF LARGE SHIPS AND OF SHIPS WITH UNUSUAL MANOEUVRING CHARACTERISTICS

THE CONFERENCE,

RECOGNIZING the importance of relevant experience and training before assuming the duties of master or chief mate or large ships or ships having unusual handling and manoeuvring characteristics significantly different from those in which they have recently served,

NOTING that such characteristics will generally be found in ships which are of considerable deadweight, length, special design or of high speed,

RECOMMENDS that:

(a) prior to appointment to one of such ships masters and chief mates should:

(i) be informed of that ship's handling characteristics particularly in relation to the subjects listed in paragraph 7 of the Appendix to Regulation II/2 — "Mandatory Minimum Requirements for Certification of Masters and Chief Mates of Ships of 200 Gross Register Tons or more" of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978;

(ii) be thoroughly familiar with the use of all navigational and manoeuvring aids fitted in the ship concerned, including their capabilities and limitations;

(b) before initially assuming command of one of the ships referred to above, the prospective master should have sufficient and appropriate general experience as master or chief mate, and either:

(1) have sufficient and appropriate manoeuvring experience as chief mate of supernumerary on the same ship or as master, chief mate or supernumerary on a ship having similar manoeuvring characteristics; or

(ii) have attended an approved ship handling simulator course on an installation capable of simulating the manoeuvring characteristics of such a ship;

(c) the additional training and qualifications of master and chief mates of dynamically supported craft should be in accordance with the relevant guidelines of the IMCO Code of Safety for Dynamically Supported Craft,

INVITES the Inter-Governmental Maritime Consultative Organizations:

(a) to keep the recommendation contained herein under review in consultation or association with other international organizations, as appropriate, particularly with the International Labour Organization, and to bring any future amendments to the attention of all Governments concerned;

(b) to communicate this Resolution to all Governments invited to the Conference.

Regulation II/4

MANDATORY MINIMUM REQUIREMENTS FOR CERTIFICATION OF OFFICERS IN CHARGE OF A NAVIGATION WATCH ON SHIP OF 200 GROSS REGISTER TONS OR MORE

1. Every officer in charge of a navigational watch serving on a sea-going ship of 200 gross register tons or more shall hold an appropriate certificate.

2. Every candidate for certification shall:

(a) be not less than 18 years of age;

(b) satisfy the Administration as to medical fitness, particularly regarding eyesight and hearing;

(c) Have approved sea-going service in the deck department of not less than three years which shall include at least six months of bridge watchkeeping duties under the supervision of a qualified officer; however, an Administration may allow the substitution of a period of special training for not more than two years of this approved sea-going service, provided the Administration is satisfied that such training is at least equivalent in value to the period of sea-going service it replaces;

(d) satisfy the Administration by passing an appropriate examination that he possesses adequate theoretical and practical knowledge appropriate to his duties.

3. Certificates for service without restriction

For issue of certificates for service without restriction as to area of operation, the examination shall test the adequacy of the candidate's theoretical and practical knowledge in the subjects shown in the Appendix to this Regulation.

4. Restricted certificates

For issue of restricted certificates for service on near-coastal voyages, the Administration may omit the following subjects from those shown in the Appendix, bearing in mind the effect on the safety of all ships which may be operating in the same waters:

(a) celestial navigation;

(b) electronic systems of position fixing and navigation for waters not covered by such systems.

5. Level of knowledge

(a) The level of knowledge to be required in the subjects shown in the Appendix shall be sufficient for the officer of the watch to carry out his watchkeeping duties safely. In determining the appropriate level of knowledge the Administration shall take into account the remarks under each subject in the Appendix.

(b) Training to achieve the necessary theoretical knowledge and practical experience shall be based on Regulation II/1 — "Basic Principles to be Observed in Keeping a Navigational Watch" and relevant international regulations and recommendations.

Article IX

Equivalents

(1) The Convention shall not prevent an Administration from retaining or adopting other education and training arrangements, including those involving sea-going service and shipboard organization especially adapted to technical developments and to special types of ships and trades provided that the level of sea-going service, knowledge and efficiency as regards navigational and technical handling of ship and cargo ensures a degree of safety at sea and has a preventive effect as regards pollution at least equivalent to the requirements of this Convention.

(2) Details of such arrangements shall be reported as early as practicable to the Secretary-General who shall circulate such particulars to all Parties.

IMCO STANDARDS OF TRAINING

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EXHIBIT B-2. TRAINING REQUIREMENTS UNDER CURRENT LICENSING STRUCTURE

Part I. Initial Requirements — Ordinary Seaman Through Pilot

ORDINARY SEAMAN

Holders of a merchant mariners document endorsed as "Ordinary Seaman" may serve as any qualified rating in the deck department. No professional examination is given for this rating.

ABLE BODIED SEAMAN (AB)

a. Be at least 19 years of age

b. Pass the prescribed physical examination

c. Pass an examination demonstrating ability as AB and lifeboatman

d. Be able to speak and understand the English language

e. Meet the sea service or training requirements for high seas and inland waters

   1. Any waters, unlimited. Three years' service on deck in vessels of 100 gross tons or over operating on oceans or coastwise routes or on the Great Lakes.

   2. Any waters, unlimited. The period of time spent by an applicant successfully completing AB training in a training school approved by the Commandant may be accepted as the equivalent of sea service up to a maximum of 1 of the 3 years required in "1" above.

   3. Any water, unlimited. Satisfactory completion of 18 months training in a seagoing training ship approved by the Commandant.

   4. Any waters. Twelve months' service on deck in vessels of 100 gross tons or over operating on oceans or coastwise routes or on the Great Lakes.

   5. Any waters, 12 months. Satisfactory completion of a course of training at a U.S. Maritime Service Training Station of at least 9 months, 6 months of which shall have been served aboard a seagoing training vessel.

DECK OFFICERS

a. Be at least 21 years of age

b. Be a U.S. citizen

c. File a written application

d. Pass a physical examination

e. Obtain a first aid certificate and pass examination based on contents of "The Ship's Medicine Chest and First Aid at Sea"

f. Supply documents attesting to experience or training

g. Acquire 25 percent of experience within 3 years immediately preceding date of application

h. Pass a professional examination

THIRD MATE

a. Obtain service on coastwise or ocean vessels of 1000 gross tons or over.

b. Present all documents (i.e., letters, discharges, or other official documents) to officer in change of marine inspection

c. Complete one of these requirements:

   1. Obtain 3 years service in the deck department of ocean, coastwise steam or motor vessels, 6 months of which shall have been as AB, boatswain or quartermaster while holding an AB certificate.

   2. Obtain 6 months service as third mate of coastwise steam or motor vessels.

   3. Graduate from one of the following:

      a. United States Merchant Marine Academy

      b. Deck class of nautical school. (Ship approved by and conducted under rules prescribed by the Commandant.)

      c. United States Naval Academy

      d. United States Coast Guard Academy

   4. Complete the prescribed course (deck) at a U.S. government-operated training school or at a recognized maritime union or nonprofit organization training school approved by the Commandant. This training may be accepted as the equivalent of sea service up to a maximum of 4 months.

   5. Obtain 1 years service as a second class pilot of steam or motor vessels of 4000 gross tons, except ferry vessels.

SECOND MATE

Complete one of the following requirements:

a. One years service as officer in charge of a deck watch on ocean or coastwise steam or motor vessels while holding a third mate license.

b. Five years service as second mate of coastwise steam or motor vessels.

c. Five years service in the deck department of ocean, coastwise steam, or motor vessels of 1000 gross tons or over, 2 years of which shall have been served as boatswain or AB.

d. One years service as first class pilot of steam or motor vessels of 4000 gross tons or over, except ferry vessels on the Great Lakes or other lakes, bays or sounds together with 6 months service in the deck department of ocean, steam or motor vessels of 1000 gross tons or over, while holding a first class pilot license.

e. Two years service as assistant to the officer in charge of the watch on ocean, steam or motor vessels while holding a third mate license.

f. Four years service in the deck department of ocean or coastwise sail vessels of 200 gross tons or over, 1 years service as second mate of such sail vessels on the Great Lakes or other lakes, bays or sounds together with 6 months service in the deck department of ocean, steam or motor vessels of 1000 gross tons while holding a second class pilot license.

g. Three years service in the deck department of steam or motor vessels on same water as in f above together with 1 years service in the deck department of ocean, steam or motor vessels, 6 months of which shall have been as AB, boatswain, or quartermaster while holding a certificate as AB.

h. Three years service in the deck department of steam or motor vessels of 100 gross tons or over engaged in the ocean or coastwise fisheries, together with 6 months service as AB, boatswain, or quartermaster on ocean, steam or motor vessels while holding a certificate as AB.

i. Satisfactory completion of 3 year apprentice mate training program approved by the Commandant.

CHIEF MATE

Complete one of the following requirements:

a. One years service as second mate of ocean, steam, and motor vessels of 1000 gross tons or over.

b. One years service as second mate of coastwise steam or motor vessels of 2000 gross tons or over.

c. Two years service as officer in charge of a deck watch on ocean, steam or motor vessels of 1000 gross tons or over while holding a second mate license.

d. Two years service as officer in charge of deck watch coastwise steam or motor vessels of 2000 gross tons or over while holding a second mate license.

e. Two years service as master on the Great Lakes or other lakes, bays or sounds, steam or motor vessels of 1000 gross tons or over except ferry vessels together with 1 years service as officer in charge of deck watch on ocean,steam or motor vessels of 1000 tons or over or together with 1 year of such service on coastwise steam or motor vessels of 2000 gross tons or over.

f. Five years service in the deck department of ocean or coastwise sail vessel of 200 gross tons or over, 2 years of which shall have been as master of such vessels for license as chief master of ocean freight or towing vessels not more than 3000 gross tons.

g. One years service as master of any class ocean steam or motor vessels of more than 250 gross tons for license as chief mate of ocean freight or towing vessels of not more than 150 gross tons.

h. One years service as mate of inspected ocean or coastwise vessels while holding an unlimited license as third mate of ocean steam or motor vessels for a license as chief mate of less than 1600 gross tons.

MASTER

a. One years service as chief mate of ocean, steam, or motor vessels of 1000 gross tons or over.

b. Two years service as second mate of ocean or motor vessels of 1000 gross tons or over while holding a chief mate license.

c. One years service as chief mate of coastwise steam or motor vessels of 2000 gross tons or more.

d. Two years service as second mate on 2000 gross tons or over coastwise steam or motor vessels while holding a chief mate license.

e. One years service as master of coastwise steam or motor vessel of 2000 gross tons or over.

f. Two years service as master of ocean or coastwise sail vessel of 700 gross tons or over for license as master of freighter or towing steam or motor vessel not more than 3000 gross tons.

g. Three years service as master 4000 tons or over except ferry vessels on the Great Lakes together with 1 years service as second mate of ocean, steam, or motor vessels of 1000 gross tons or more.

h. Two years service as licensed master of ocean or coastwise or as licensed ocean operator of mechanically propelled passenger carrying vessels operating on limited ocean or coastwise routes for a license as master of passenger vessel not to exceed 2000 tons.

i. Written endorsement of master and two other licensed officers of a vessel on which he has served as pilot, one endorsement must be from a licensed pilot of a vessel on which he has served for a character check.

PILOT

a. Must have letters or other documents certifying the name of vessels, the periods of service, dates and number of round trips made, and capacity in which applicant served.

b. Three years service in deck department of ocean, coastwise, Great Lakes or bays, sounds and lakes other than the Great Lakes, steam or motor vessels, of which 18 months shall have been as AB or service in a capacity at least equivalent of AB.

c. At least 1 year on vessel operating on the waters of the class for which pilotage is desired in capacity of quartermaster, wheelman, AB or equivalent, who stands regular watches at the wheel or in the pilot house as part of his routine duties and:

   1. Twenty-five percent of such service shall have been obtained within 3 years immediately preceding the date of application.
   2. Minimum number of trips as specified by officer in charge.
   3. One trip shall have been made over the route.

d. Graduation from the Great Lakes Maritime Academy in the deck class or:

   1. Three years service in deck department of any vessel of which at least 1 year shall have been on vessels operating on the waters of the rivers while serving as quartermaster, wheelman, or deckhand who stands watch of the wheel as part of his routine duties.
   2. Two years service in the deck department of master vessels navigating canals and small lakes, such as the New York State Barge Canal and Seneca and Cayuga Lakes in state of New York, 1 year will have been within the 2 years preceeding date of application.
   3. Limitation shall be imposed commensurate with past experience class of vessels for which valid, tonnage, route and waters.

e. Pass examinations for pilot license. Subjects included are:

   1. Rules of the Road
   2. Inland Rules, applicable to route
   3. Local knowledge of winds, weather, tides, current, etc.
   4. Chart navigation
   5. Aids to navigation
   6. Shiphandling
   7. Chart sketch of the route and waters applied for, courses, distances, shoals, aid to navigation, depths of water, and other important features of the route (i.e., pollution abatement)
   8. Other examinations deemed applicable to establish applicants proficiency
   9. For route extension of master, applicant will be tested on 1,2,7 and 8

Part II. Requirements for Raising Grade of License

Requirements for raising the grade of a license:

a. Surrender old license

b. Be at least 21 years of age

c. Submit a written application

d. Same as for original license

e. Obtain 25 percent of required sea service within 3 years preceding date of application. Service time for prior license is not to be accepted as any part of the service requirement.

f. Pass a professional examination

Part III. Requirements for Renewal of License

GENERAL

a. Submit a written application.

b. Demonstrate a knowledge of pollution abatement equivalent to that required for an original license.

The license will be received within 12 months after expiration date. No license shall be renewed more than 90 days in advance of the date of expiration.

MASTERS, MATES, OR PILOTS

a. For 3 years preceding application, demonstrate knowledge of Rules of the Road in general and specifically for waters for which applicant to be licensed.

b. If applicant has not served within 3 years preceding date of application, he must take written exam of Rules of the Road or oral exam.

c. Applicant must meet physical requirements:

1. Normal color vision
2. Must have completed physical examination by medical officers of PHS

If applicant is not in country and cannot present himself to an officer in charge of marine inspection, he can renew the license by mail. To reissue an expired license, the applicant must pass an examination of the same grade of license held.

MASTERS, MATES, OR PILOTS WITH RADAR ENDORSEMENT

a. Meet experience requirement

b. Demonstrate knowledge of:

1. Fundamentals of radar
2. Operation and use of radar
3. Interpretation and analysis of radar
4. Plotting within 36 months before date of application.

(If master, mate, or pilot has a certificate from approved radar training course within 12 months of date of application, he does not need to take written test.)

APPENDIX C

TRAINING PROGRAM SPECIFICATIONS

C.1 INTRODUCTION

The conditions which must be met to produce an effective training program are the subject of this section. The conditions are discussed in the form of structural requirements for training. These requirements make up, in part, the design of a training program to ensure validity. Validity defines the effectiveness of training in meeting the objectives of the maritime industry. Training techniques and feedback methodologies used in the learning process relative to skills and abilities are discussed with reference to the degree of learning retention produced. Lastly, performance measures for differing training objectives are provided. The validity, reliability and sensitivity of these measures however, must be established, and performance standards specified. The intent of these training specifications is to provide an adequate structure within which a training program can take form.

C.2 METHODOLOGY

The literature was reviewed to determine how the following factors impact an adequate training program structure:

a. Learner characteristics and individual differences

b. Training methods

c. Training effectiveness

d. Performance measures and standards

The literature was reviewed to determine the range of training specifications available, their applicability to a maritime training program, and the effect of learner characteristics on their selection and use. Training analysts reviewed the set of skill requirements (see Exhibit A-5) and identified those information characteristics (e.g., color versus black and white, or spatial orientation) required to train each skill. They then determined which of the feedback methodologies and training techniques researched in the literature were required for the effective acquisition and retention of each skill. The set of specific functional objectives, developed in Appenidx A (see Exhibit A-8) was also reviewed and appropriate performance measures selected.

C.3 RESULTS AND FINDINGS

C.3.1 Learner Characteristics and Individual Differences

Any large scale training program must be standardized. Standardization precludes tailoring a training program to the individual. However, it has been shown that groups of individuals perform differently, depending upon the method of instruction used. Since training can be enhanced by the use of various instructional methods relative to the learning styles of different individuals, such methods should be considered in the structure of the program. Learning styles are operationally defined as the enhancement of learning

under one set of circumstances and its impedence under another set, when the difficulty levels of the material and the aptitude of the individuals are similar.

Tallmadge et al (1968) have shown that two general methods of instruction, deductive and inductive, can be used to either enhance or impede training based upon learner characteristics. These two methods have also been referred to as rule-example (deductive) and example-rule (inductive) instruction (Anderson, 1967 and Krumboltz and Yabroff, 1965). Tallmadge et al (1967) have provided a thorough review of individual characteristic variables which affect learning. These investigators concluded that the existence of learning styles does interact significantly with the type of subject matter to be learned. Such learner characteristic differences could be incorporated into a multi-track training program by providing independent training modules for the different classes of learning styles. There is insufficient evidence to determine what types of subject matter, relative to shiphandling, can be enhanced through the use of these two methods of instruction. This approach to the specification of instructional training methods should be considered for further research efforts.

C.3.2 Training Methods

C.3.2.1 General Versus Specific Training. Of major concern in the development of any training program is the decision of training general abilities or specific skills. Ability training is designed to provide the individual with broad-based skills which can be applied to a variety of different tasks. Skill training, on the other hand, is designed to incorporate only those specific skills necessary for the learning of a specific task (Hogan, 1978). Learning of some general abilities may be a byproduct of skill training. This occurrence is referred to as "learning to learn" (Postman and Swartz 1964). For example, training an individual in collision avoidance problem-solving on a variety of radar or CAS systems will allow that individual to transfer his knowledge of collision avoidance problem-solving to systems on which he has not had prior experience. Thus, in the long run general learning and specific learning do overlap somewhat.

Learning to learn as a general ability, as opposed to specific task training, will provide the trainee with greater flexibility and generalizability of skills in a variety of situations. Morrisett and Horland (1959) and Duncan (1958) have shown that the degree of variation in training, as opposed to constant training on a single task, produces the greatest transfer of training. In short, variation per se seems to be the key factor in training for positive transfer.

On the basis of the literature reviewed (specifically Hogan, 1978; Fleishman, 1972; and Fleishman and Ellison, 1969), ability training will provide for the greatest positive transfer of training. Since positive transfer of training is an important objective of training, it is suggested that those general abilities involved in all aspects of shiphandling be identified and incorporated into the proposed shiphandling training and certification program.

C.3.2.2 Part Task Versus Whole Task. The part-task versus whole-task methodology of training addresses the issue of task integration. That is, can training on specific tasks, independent of the sequence of tasks being trained, be easily transferred to a situation in which all of the trained task skills are integrated into a "whole task"? Attempts to answer this question have created a further segmentation of the part-task versus whole-task continuum. Briggs et al (1962) undertook a rather comprehensive study of this continuum which is representative of the findings on this topic (Naylor, 1962).

Briggs et al (1962) have added two additional levels to the part-task/whole-task continuum. The entire continuum is then structured as follows:

- Pure part training — The trainee experiences or practices on the several components of the task, one component at a time.
- Progressive part training — The trainee learns several part tasks, then works on different combinations of the parts until he builds to the total or whole task.
- Simplified training — The trainee learns on a simplified version of the whole task. An issue of special significance using this method is that of fidelity of the training task.
- Whole-task training — The trainee learns all of the components of the complete task and does not train on any fraction of the whole task.

These levels of part-to-whole task training were assessed experimentally. The results indicated that:

- Pure part training is the least effective method for acquisition of the whole task.
- Simplified training is really a question of task fidelity.
- Progressive part and whole-task training are the most effective techniques, but are dependent upon the level of complexity and degree of organization of the task to be trained.

With respect to the latter finding, a complex and highly organized task will be learned more quickly under whole-task training; a complex but relatively unorganized task will be learned more quickly under progressive part training; and a task of low complexity will be learned more quickly by whole-task training independent of the level of task organization.

In general, then, progressive part training should be the primary method for the training of complex tasks that are highly unorganized and whole-task training should be the primary method for all others.

C.3.2.3 Individual versus Team Training. A team has been defined by Wagner et al (1976) as having the following characteristics:

a. They are relatively rigid in structure, organization, and communication patterns.

b. The task of each team member is well defined.

c. The functioning of the team depends upon the coordination and participation of all or several individuals.

Individual training, on the other hand, is solely concerned with training skills not involving the coordination of other individuals. As shall be discussed, however, it is quite difficult to separate the training of individuals from the training of teams.

Some aspects which are of fundamental importance in understanding team training are:

a. Task organization

b. Type of communication between individuals of the team

c. Fidelity of the training situation

d. Type of feedback

Task organization. Task organization has been discussed by several investigators (Wagner et al, 1976; Briggs et al, 1967; Briggs and Johnston, 1966; and Briggs and Naylor, 1964). From these investigations four basic types of task organization have been identified:

a. Established — in which the tasks and activities to be performed can be completely specified;

b. Emergent — in which all tasks and activities cannot be specified and the consequences of certain actions cannot be predicted

c. Parallel — in which the performance of an individual does not depend on the performance of team members

d. Series structures — in which performance is based upon all members of the team including the poorest performer

The emergent situation is the one most closely related to real world conditions, since the individual is allowed the flexibility to respond to unexpected events. Since performance is not completely specified, however, measuring team performance is difficult.

In series structured tasks performance is truly based upon a team rather than individual effort. Briggs and Johnston (1969) have demonstr ed that whereas performance in the parallel structure is not disrupted when a member of the team is replaced, it is initially disrupted in the series structure. This disruption can be easily overcome if the replacement member has highly developed skills.

Types of communication. Briggs and Johnston (1966) have found that under full channel availability (i.e., both visual and verbal communication) among team members, system performance is facilitated. Nevertheless, verbal communication should be restricted to essential and simple information. Krumm and Farina (1962) have also concluded that things are better done than said. The less interoperator verbal communication, the better. It appears then that visual communication offers the greatest improvement in team performance.

Fidelity of the training situation. The fidelity of the team training situation is one of the single most important aspects affecting transfer of team training to the real world. Wagner et al (1976) have found that high fidelity is essential for interactive training. Additionally, Briggs and Naylor (1964) found that high fidelity was not limited simply to teams requiring interactive training but also to teams not requiring a high degree of interaction. In general most studies concerned with team training have found that high fidelity is essential for positive transfer, independent of the degree of interaction among team members.

Type of feedback. The literature indicates that due to the complexity of team training it is often difficult to determine those aspects of behavior which require feedback (or knowledge of results) to promote optimal performance. Studies that have provided feedback contingent upon communication have found that team members are distracted from the primary task and give preference to communication consequently reducing task performance. Klaus and Glazer (1970) and Slovic and McPhillany (1972) have indicated that it is best to provide the trainee with critical feedback either immediately before or after a training session rather than to disrupt the session. Incorrect behavior should be delineated before a deficiency is allowed to occur, rather than corrected after it occurs.

Furthermore, feedback following training sessions allows team members to assess their performance as a whole in retrospect and to discuss their activities as a team. The interjection of feedback during a training session only serves to retard team performance.

In summary, team training apparently is not greatly disrupted if a highly trained individual is substituted for a team member. Therefore, it appears that training individual skills is important to the development of proficient team performance (Horrocks et al, 1961). Since most real world team efforts must accommodate the unexpected, team training should allow for some flexibility as opposed to a rigid definition of task requirements and procedures. Feedback should be nondisruptive and anticipatory when possible. Lastly, high fidelity in the team training situation is crucial to positive transfer of training to the real world.

C.3.2.4 Feedback Methodologies. Of fundamental concern to any learning or training program is feedback. Feedback can be defined as any information which follows as a consequence of either a psychological or physiological response. The significance of feedback was first empirically established by Thorndike (1913) who proposed the law of effect which states that the strengthening or weakening of a behavior is determined as a result of the consequence associated with that behavior. This statement of the importance of consequent behavioral events is a consistent theme in all major theories of learning which have gained any empirical credence (Hilgand and Bower, 1966). Thus, feedback is a vital component of the training process. It can be as simple as "correct" or "incorrect" verbalized by an instructor or indicated by an instrument. It may also include the trainee's own self-evaluation. Feedback can be a cue which is visual, aural, tactile, or vestibular (obtained through a sense of motion).

Knowledge of results (feedback) in its many forms may facilitate or inhibit learning to an almost infinite degree. Pesch, Hammell, and Ewalt (1974) conclude and emphasize that feedback must:

- Be timely
- Contain useful information
- Be meaningful
- Be communicated in operational terms

In essence, feedback must be suited to the training situation, to the level of the trainee, and to trainee performance. It can be broken down into the following dimensions:

a. Recipient of feedback. The distinction must be made whether the feedback is received by an individual or a team. Feedback presented to an individual usually is direct, while feedback presented to a team may be compounded due to the number of individuals involved. The team must take the feedback and assimilate it both individually and as a team (Hammell, Sroka, and Allen, 1971; and Hammell, Gasteyer, and Pesch, 1973).

b. Source of feedback. Three sources of feedback are frequently cited as existing in training situations:

   - Intrinsic -- that which is received from the trainee's own movements
   - Action — that which is received from the system
   - Achievement — that which is provided externally to the system

c. <u>Timing of feedback</u>. A distinction is made between immediate and delayed achievement feedback. Immediate knowledge of results can be provided to the trainee from a computer simulation which provides real-time printouts or from programmed texts in which the trainee checks his own progress and answers. It has been found that immediate feedback is necessary at the outset of a training program; whereas delayed feedback may be appropriate later in the program. When the trainee is at the lower level of skill early in the training program, he will benefit from immediate feedback to correct each deficiency and reinforce each proficiency as it occurs. This is considered a developmental period. Later in training, however, as the trainee achieves a higher level of skill and the training situation become more similar to the operational environment, delayed feedback is more appropriate. It will give him time to realize his own mistakes before being cued and reduce the possibility of the trainee's becoming dependent upon feedback in the operational environment. Klaus and Glaser (1970) recommend that extensive reinforcement be provided during the early stages of training and progressively leaner reinforcement ratios as the trainees become more efficient.

The length of the feedback delay, of course, can vary substantially. Feedback delayed until the end of a simulator exercise, for example, prevents the trainee from using it as a "crutch". Prolonged delay, however, can be detrimental to learning and is one of the most common reasons for user rejection of simulation training.

The reason for prolonged delay in feedback in simulator training, while not recommended, is understandable. Simulators are frequently utilized to the extent of their capacity, thus allowing little time to review scenarios or re-run exercises. However, it makes theoretical and practical sense, particularly when a trainee is learning a new skill, that some sort of immediate feedback is necessary to encourage him and to keep him on the desired path.

d. <u>Appropriateness of feedback</u>. One measure of the effectiveness of a training program is the appropriateness of feedback, that is, the degree to which the feedback aids learning by its applicability.

e. <u>Problems pertaining to feedback</u>. Caro (1977) outlines problems pertaining to feedback such as including nonusable information in the training. This could result in attention being paid to the wrong information as feedback. Distractions and bias as a result of peripheral influences could also result.

In conclusion, Hall and Rizzo (1975) point out that "some form of feedback, or Knowledge of Results (KR), is essential to the learning process." Trainees need to know how well they are doing during training to ensure that they are acquiring the proper information. The authors also point out that all the simulator sites which they visited employed sporadic, nonsystematic feedback in a very casual fashion; suggesting that, "how much, when, and what kind of feedback trainees receive seems to be a function of individual instructor practice rather than unit practice or policy." After their review of research literature on feedback, Kanarick et al (1971) concluded that "performance feedback is unquestionably the single most important parameter in team or individual training." As further emphasis, Daniels et al (1972) stress that feedback "to be maximally effective, should be specific, overt, immediate, complete and positive."

Various types of feedback exist. Feedback is discussed below in terms of differing psychological and physiological systems involved in the feedback process.

C.3.2.4.1 Classes of Feedback. There are two basic classes of feedback: intrinsic and extrinsic. Intrinsic feedback is supplied automatically by the physiological or psychological systems as the result of some action. Extrinsic feedback is supplied by external sources. Intrinsic feedback is preattuned to the human system. That is, we can know the position of one of our extremities in space without any form of information supplied by external cues. This kind of feedback is also referred to as proprioception (i.e., the perception of one's muscular system as well as one's internal state as a result of information being relayed by the nervous system to the brain, where the information is processed, supplying us with knowledge of our internal and external status). For a review of these basic classes of feedback, consult Annett (1961) or Weisz and McElroy (1964). Although there are numerous other references which can be cited, those mentioned are specifically associated with the topic of training.

a. Knowledge of Results (KR). A term used synonymously with feedback in the literature is "knowledge of results" (KR). Many methods exist of supplying KR to the trainee. Most of these methods involve some form of extrinsic feedback.

b. Augmented Feedback. Augmented feedback, a method for presenting KR, has been employed in training to supply additional information secondary to a primary feedback signal. For example, in the training of a tracking task the return from radar or sonar can be augmented by auditory signals which are concurrent with the visual display of a target on a PPI (Micheli, 1966). It has been found by several investigators (Schafer and Schumacker, 1953 and Gebhard, 1947) that the augmenting of such visual information by a secondary, auditory signal decreases the probability of a failure to detect a target for both radar and sonar displays. The one shortcoming of this procedure is that augmented feedback is usually not supplied by the conditions of the real world and in some cases augmented feedback in the training situation can retard positive transfer of training. This may likely be due to a conflict in terms of what the trainee expects to happen as a consequence of his actions. On the other hand, the increased information supplied by augmenting cues has been found to enhance positive transfer for some tasks. Augmenting feedback has also been found to affect the motivation of the trainee (Annett, 1961) by providing him with additional information to guide his response. (For a review of augmenting feedback and transfer of training, see Micheli, 1966.)

c. Quality and Timeliness of KR. KR has also been used in training situations which require the trainee to make complex discriminations such as in many visual detection tasks. With respect to such fine discriminations, simplicity and speed of feedback in whatever form is extremely important (Weisz and McElroy, 1964). KR thus serves to inform the trainee of the salient features of the environment to which he must attend to optimize task performance. Others have emphasized that positive KR is more conducive to the learning process (Trowbridge and Cason, 1932). Regarding delay in feedback, it would be considered prudent to supply feedback in a manner consistent with what one would expect in the real world. For example, if there is a delay in the perception of the rate of turn of a vessel due to its sluggishness, feedback in training should be consistent with this delay. (See also C.3.2.4.c above.)

d. Action Feedback. Action feedback (Miller, 1953) or guidance feedback is another method used to inform the subject as to the next item in a sequence of actions. This form of feedback is found to be highly effective in tactical decision-making training (Pesch, Hammell, and Ewalt, 1974).

e. Effect of KR on Cognition. In keeping with the cognitive movement presently dominating the field of psychology is the effect of KR on the development of schema discrimination. A schema is defined as a set of rules which would serve as instructions for producing an expectation about a class of attributes which make up certain objects (Evans, 1967). The schema is produced to reduce information processing and storage requirements for objects which have redundant aspects. Objects which vary from the schema would be stored only with respect to those aspects which deviate. The learning of such rules with respect to identifying and recognizing specific aspects of objects has been considered to be a spontaneous process on the part of the individual. Accordingly, it has been found that KR does not appear to affect the learning of schema and that humans can learn to distinguish between them (Edmonds, Mueller and Selby, 1966) without external assistance. However, the formation of schema as a fundamental cognitive process can be considered to be intrinsically reinforcing and thus be thought of as a form of intrinsic feedback. More concisely, there are forms of learning to organize the environment or task situation that occur spontaneously as a fundamental human trait. Such learning to date has been found to be independent of external KR. It therefoi should be noted that KR is unnecessary for specific aspects of training. Such aspects should be identified so as to increase the efficient, effective use of KR.

C.3.2.5 Training Techniques. Training techniques are structured or unstructured methodical approaches to the training process. They are frequently derived as the result of a training philosophy and, as such, may be more appropriate in some applications than others. Seventeen training techniques are briefly presented below.

a. Positive Guidance. Positive guidance is "a technique whereby relevant information concerning the appropriate behavior is provided to the trainee prior to his actions in a training situation" (Pesch, Hammell, and Ewalt, 1974). Several authors have suggested that it is better to initiate correct behavior than to let a mistake occur and then try to correct it (Klaus and Glaser, 1970; and Slovic and MacPhillany, 1971).

Slovic and MacPhillany found that in some instances critical feedback given to the trainee did not aid his performance, but instead disrupted his thought processes. This led to degraded performance in certain situations, where a positive guidance approach might have proved effective. Positive guidance is provided when the instructor directs the trainee and provides correct procedures during the exercise. This type of guidance is most effective in individual training with direct interaction between a student and an instructor.

Prompting and indirect guidance are modifications of positive guidance. Prompting is best used in a team context for an individual who may be less competent than the other team members. Indirect guidance encourages correct behavior by indirect means, such as the instructor asking appropriate questions at prop . times. Correct behavior is encouraged because trainees are directed toward performing behavior associated with the questions as the problem progresses.

b. Self-evaluation. Self-evaluation is a training technique whereby the trainee evaluates his own performance on the basis of feedback information supplied by the trainer. This is in direct contrast to positive guidance, where the

correct procedure is actually demonstrated or explained first. Self-evaluation is more appropriate for advanced training of complex skills such as decision-making in which a variety of acceptable trainee approaches may exist. It has the advantages of "requiring or focusing insight into complex problems enabling the selection and evaluation of alternate solutions and describing the desired trainee behavior at an intra-task level" (Pesch, Hammell, and Ewalt, 1974). The technique of self-evaluation is most effective when directed as specific behavior patterns.

c. Individualized Curricula. This technique responds to the idea that decision making is highly individualized; thus, the training approach must be tailored to the range of trainee differences. Its most important asset may be "the ability of the training system to adjust to the characteristics of the trainee with respect to his ability to clearly understand the decision process on common ground with the intent or objective of the training" (Pesch, Hammell, and Ewalt, 1974). The technique implies a detailed treatment of guidance information as provided by a very good instructor. "This guidance information should reference the trainee path, his previous deficiencies and proficiences and generate a prescriptive course of individualized instruction," according to the authors. In essence, a diagnostic evaluation of the strength and weaknesses of the individual is made and then the curricula is tailored to facilitate learning.

d. Knowledge of Requirements. Knowledge of requirements involves the revelation of all training objectives (i.e., what the trainee is expected to learn). Telling the students what they need to learn structures the learning situation and provides a training set. Such a technique applies to all levels of training and is used with great success in conjunction with other techniques.

e. Demonstration. Demonstration provides the trainee with a correct example of operations or procedures during classroom time. This includes familiarization with new equipment and operations; and is well suited to both individual and team training.

f. Structured Problem. Structured problems are arranged in terms of relative complexity and difficulty so as to be interesting enough to maintain the students' attention. Diagnostics can be used to determine the level and particular exercise required for any trainee and/or training situation.

g. Immediate Repetition. Immediate repetition emphasizes correct methods by stopping the problem when an error occurs, dramatically illustrating the error, and then demonstrating the correct behavior. Such an approach is suitable following the use of positive guidance by repeating the drill as often as required.

h. Adaptive Training. Adaptive training is a strategy of training which varies the task difficulty as a result of how well the trainee operates or performs on a specific task. The strategy makes the trainee's task more difficult as he gains in skill. Such a training technique has been automated for simulator training and proven to be extremely useful and effective. In essence this form of automated training takes the place of the skilled instructor who would normally keep the level of difficulty of the student's task to that which is appropriate for the skill level at which the student is functioning. Such an automated system would be most efficient in terms of processing trainees and

increasing objectivity, allowing the instructor to attend to more important aspects of training aside from adjusting the difficulty level of the training task (Kelly and Wargo, 1968).

i. Prediction Training. Substantial evidence indicates that training to control a vessel in complex maneuvers is highly correlated to learning to predict the future state of the vessel. This is of considerable concern to the training of shiphandlers who are required to make judgments about the state of their vessel far in advance of their actions. With the slow response time of large vessels, such training could be particularly relevant to the upgrading of the mariner's shiphandling performance. Therefore, it is recommended that prediction training be a seriously considered aspect of the long term USCG training program. The technique of prediction training has to date been shown to be extremely helpful in the acquisition of a complex orbital docking task which also involves relatively slow vehicular response times (Kelly et al, 1966).

j. Postproblem Critique. Postproblem critique is a method of providing delayed performance feedback. It is best suited for advanced levels of complex training that can be broken into short segments. It can be used to:

- Emphasize strong points
- Point out specific errors in performance and procedures and provide directions for specific correction
- Provide specific instructions on changes for the next session or part, or for post operational briefing
- Provide an opportunity to demonstrate correct behavior
- Provide an opportunity to demonstrate correct procedures
- Provide an opportunity to demonstrate the proper interpretation of audio and visual displays

k. Experience Enhancement. Experience enhancement provides an overall awareness of the problem through the trainee's observance of similar problems from several vantages other than his own. Using this technique, an individual's performance is increased by providing an understanding of information requirements by other personnel in the conduct of their tasks. Situations of intermediate and high level difficulty are best suited to this technique.

l. Contrast and Comparison. The contrast and comparison method demonstrates why one particular procedure or method is better than another. A certain exercise is run using the supposed optimum procedures and operations and then rerun using alternate operations. This technique enables trainees to learn by comparing their results in one trial with the results of another.

m. Direct Exposure or Work-through. In direct exposure or work-through, the trainee immediately performs the required task at the initiation of training. This technique allows trainees to develop skills by doing problems with minimal instructor involvement. The highest level of effectiveness of this method may be reached if an appropriate level of complexity is selected. It is beneficial as refresher training for knowledgeable personnel, but must be used carefully because negative training can occur if bad habits or improper procedures are allowed to develop. Direct exposure or work-through is best applied to advanced level exercises.

n. Task Variety. In this technique the instructor uses a variety of situations of about equal difficulty to illustrate common errors and shortcomings in procedures. The technique further aids the student in detecting these weaknesses when they occur. Effective use of task variety can be realized when a combination of individual and team training is necessary. Here, one team member may be acquiring individual training while the whole team benefits.

o. Team Awareness. The technique of team awareness reveals each person's strengths and weaknesses during team operation so that team members can learn to compensate for one another. This method requires interpersonal feedback so that each and every individual knows where he and everyone else stands as part of the team.

p. Common Error. When utilizing the technique of common error in a carefully described exercise, the instructor allows the trainee to commit the common mistake, then immediately and emphatically corrects him. This approach is used only in extreme situations where a positive approach might not be effective. Common error is used to train out previously learned, undesirable behavior.

q. Self-Instruction. In this technique, the trainee learns a subject through teaching it to others. The assumption is that a concept is most thoroughly learned when one is forced to communicate it. This method is most effective in a team context.

All of these techniques are used to obtain a high level of performance from trainees. As exercises are developed, selection of training techniques must be based upon:

- The intended results
- The skill levels involved
- The training objectives
- Time required for training
- Availability of staff personnel
- Training aid availability and requirements
- Overall cost

Each skill requirement was examined to determine the most appropriate training techniques and methodologies. This information is listed in tabular form in its entirety in Exhibit C-1.

Once the appropriate techniques for each skill were established, the information characteristics required to train these skills were examined. Twenty-five information characteristics (such as color, size of image, motion, brightness, distortion of input information, auditory frequency, obscured vision, spatial orientation) were listed and matched to each skill. (See Exhibit C-2.) See also Appendix E, Exhibit E-1 for a more detailed discussion of information characteristics.

C.3.3 Training Effectiveness

Training effectiveness has several facets: validity, efficiency, and practicality. Validity measures the ability of a training program to accomplish its objectives; that is, does it work? Although this would assumedly be a prerequiste for any training program, many training programs have been developed that either partially address or ignore this question (Goldstein, 1978). One method of determining validity is through establishing positive transfer of training from the training to the operational situation, as discussed in section C.3.3.1 below.

Efficiency measures the ability of a training program to reduce the time required for trainees to acquire defined skills and knowledge or a specified level of performance, as discussed in section C.3.3.2 below.

Practicality measures the factors of cost, safety, and technology in determining whether a training program can be realisitcally effected. These factors must be traded off whith the validity and efficiency of a program in assessing its overall value (Blaiwes et al, 1973). Thus, for example, a training program may meet rigid validity and efficiency standards, but be impractical because of cost, safety, or the state of the art in simulator hardware.

C.3.3.1 Method of Establishing Transfer of Training. Transfer of training is usually assessed by comparing an experimental group with a control group. The experimental group is trained within the training program to be evaluated, while the control group is either: (a) not trained at all, (b) trained in an unstructured training program, or (c) trained within a strucutred program thought to be inferior to that of the experimental one. After training is completed for both groups, trainee performance is evaluated in the operational situation. Performance measures for both groups are evaluated and compared. If the performance of the experimental group is superior to that of the control group, the training program under evaluation has promoted positive transfer of training. If performance is inferior, it has promoted negative transfer of training.

The term, transfer of training, is also commonly applied to positive or negative transfer of training between systems, rather than between the training situation and the operational situation. It refers to the ability to apply skills acquired in a specific context to a different context requiring similar skill elements. However, when the transfer of training occurs between the training and operational situations whether from this specific training context to the parallel operational context only, or to several similar operational contexts, the validity of training is established.

C.3.3.2 Method of Measuring Efficiency of Training. One method of measuring the quality of training is the "transfer effectiveness ratio" (TER) discussed by Roscoe (1971). For example, a form of simulator training in an experimental training group saved 9 hours of training in the operational situation to meet a specified level of performance. The total training time in the operational situation alone was 45 hours. The total training time for the experimental group was 18 simulator hours and 18 operational hours. The savings amounts to a 20-percent increase in efficiency of training. As stated above, the difference between the control and experimental groups in terms of time saved is: 45 hours (control) - 36 hours (experimental) = 9 hours. The TER expresses this savings as:

$$\frac{\text{control - experimental hours}}{\text{simulator hours}} = \frac{45 - 36}{18} = 0.5,$$

0.5 operational training hours saved for each hour spent in simulator training. The specification of a criterion level of performance and the problem of performance measures in general are the topic of the following section.

C.3.4 Performance Measures and Standards

The set of SFOs developed in Appendix A lists the behaviors and conditions under which they should be accomplished. One vital element however, is missing -- the measures and standards to objectively evaluate performance. The set of SFOs was examined and 76 applicable performance measures and standards were created (see Exhibit C-3). Training analysts then determined which of these 76 measures and standards would apply to each SFO to evaluate a trainee's performance. (See Exhibit C-4.)

Prior to determining these performance measures and standards, the fundamental concepts affecting their development had to be determined. These include validity, reliability, objectivity, and sensitivity.

Validity of Performance Measure. Validity establishes whether a measure actually reflects the behavior or performance for which it was intended. To evaluate the validity of a measure, it could be deemed valid if highly correlated with other known valid measures of performance. Following this logic, however, one could then question the validity of the original measure, and on ad infinitum. Ultimately, the validity of a measure depends upon agreement among knowledgeable individuals. Thus, for any one measure, there is a continuum of validity.

Validity can then be expressed in terms of the variation of agreement on a measure. Each measure for which a large number of scores exists can be formed into a distribution with an average value (mean) and a measure of dispersion (standard deviation). This distribution then supplies the observer of the behavior to be trained with a baseline reference (i.e., level of performance) to which scores from other individuals of the trainee population can be compared.

Since the distribution of scores has been defined with respect to the frequency of occurrence of any specific score, the observer can then establish other standards, which reflect different frequencies relative to the mean and which signify differing levels of performance. Such standardized measures indicate how a score compares to others obtained from the population. If it is highly unlikely that a score will be obtained which exceeds a mean or average value, then that score would indicate that the standard of performance is greater than average and would be qualitatively assessed as better. On the other hand, if the frequency of occurrence of a score is highly unlikely, since it is so low with respect to the average, the performance reflecting that score would be qualitatively assessed as being poor. Therefore, standards of performance are all relative to the distribution of frequencies of occurrence made up of scores obtained from a representative group of individuals (i.e., those who possess characteristics in common with those individuals who are to be the subject of the training program).

When the distribution for each measure of performance has been obtained, one can assess the progress of the trainee over a period of time when given varying experiences. If his scores on these performance measures increase in terms of what one would expect, it would be said that the trainee is learning and becoming more proficient in developing the

skills necessary to accomplish his task. Measures should therefore be addressed to the question of how to tell when a student's training should end (Jeantheau and Anderson, 1966).

Reliability of Performance Measure. Briefly, reliability refers to the degree of variation in a score barring any effects due to training or learning. A reliable score is one that will not vary greatly over time in the absence of any additional training or learning. A score is not reliable if it varies greatly over time independently of any training variable.

Objectivity. Several classes of measurement of varying objectivity are used to differentiate among individual scores. They are, in ascending order of objectivity and relability, nominal, ordinal, interval, and ratio. Nominal measures refer to the classification of items into discrete groups that do not bear any magnitude relationships to one another. For example, we may have a sample of vessels which are to be classified as VLCC, containership, or LNG. In classifying each vessel, a nominal measure is created.

Ordinal measures involve assigning a rank to each piece of data. The difference between each ranked position is not equal and therefore does not specify any reliable interval difference between two data points. An example of ordinal data would be the rank ordering of various vessels by positioning them from largest to smallest based solely on perception.

Interval measures, in contrast, specify a difference between two scores in terms of a standard interval separating them. An example of an interval measure would be the speed increase of a vessel. One vessel may increase its speed from 14 to 16 knots, while another vessel increases its speed from 6 to 8 knots. The interval measures are relatively reliable and objective. However, the absolute magnitude of two sets of data points which both differ by 2 knots is unknown. That is, the difference between 14 and 16 knots is 2 knots as is the difference between 6 and 8 knots. The measure is 2 knots. The absolute magnitude of the data points from which the interval measure of 2 knots was obtained is lost.

A ratio measure sets a standard reference. With a ratio measure, absolute differences are not lost, since the reference is always the same. For example if the weight of one vessel is twice that of another, the absolute magnitude of the measures is considered. Intuitively, a ratio measure is the most objective, since its reference or standard is exactly specified. Interval and ratio measures appear to be the best choice for determining differences in performance due to their reliability and objectivity.

Sensitivity. Sensitivity reflects the ability of a measure to distinguish finite degrees of difference in performance. Choosing reliable, objective measures, facilitates the problem of determining sensitivity, since such measures do not vary. Consequently, the performance measures proposed for assessing trainee performance will, whenever possible, consist of interval and ratio measures.

All measures recorded will be standardized so that progress in performance can be monitored as a function of the training variables used in the program. By standardizing all scores, baseline performance can be established and pre- and posttraining performance can be assessed. Minimum useful performance, normal performance, and maximum performance standards can thus be statistically determined to assess the proficiency of each trainee in terms of skill performance.

C.4 CONCLUSIONS AND RECOMMENDATIONS

From the study, the following conclusions and recommendations regarding training program specifications have resulted:

a. The existence of learning styles does interact highly with the type of subject matter to be learned.

b. A degree of variation in training as opposed to constant training on a single task produces the greatest transfer of training.

c. Ability training will provide for the greatest positive transfer of training.

d. In general, the progressive part and the whole-task methods are the most effective training techniques, but the level of complexity and degree of organization of the task to be trained affects the selection of technqiues.

e. A complex and highly organized task will be learned more quickly under whole task training.

f. A complex but relatively unorganized task will be learned more quickly under the progressive part method.

g. A task of low complexity will be learned more quickly by the whole method, independently of the level of task organization.

h. For visual, verbal, or visual/verbal communications, visual communication offers the greatest improvement in team performance.

i. High fidelity is essential for positive transfer, independently of the degree of interaction among team members.

j. Team training is not greatly disrupted if a highly trained individual is substituted for a team member.

k. It is best to provide the trainee with critical feedback beforehand or immediately following a training session, rather than to disrupt the ongoing behavioral training trial.

l. Feedback, to be maximally effective, should be specific, overt, immediate, complete, and positive.

m. Feedback must be suited to the training situation, to the level of the trainee, and to trainee performance.

n. Extensive reinforcement must be provided during the early stages of training, with progressively less as the trainee becomes more efficient.

C.5 RESEARCH ISSUES

The following research issues have been identified:

a. Usage of inductive versus deductive methods of instruction

b. Relative effectiveness of training methods

1. General
2. Specific
3. Pure part
4. Progress part
5. Simplified
6. Whole task
7. Individual
8. Team

c. Relative effectiveness of factors related to feedback

1. Recipient
2. Source
3. Timing
4. Appropriateness
5. Pertinent problems

d. Relative effectivess of feedback methodologies

1. Knowledge of results
2. Augmented feedback
3. Intrinsic
4. Extrinsic

e. Relative effectiveness of training technqiues

1. Positive guidance
2. Self-evaluation
3. Individualized curricula
4. Knowledge of requirements
5. Demonstration
6. Structured problem
7. Immediate repetition
8. Adaptive training
9. Prediction training
10. Postproblem critique
11. Experience enhancement
12. Contrast and comparison
13. Direct exposure or work-through
14. Task variety

15. Team awareness
16. Common error
17. Self-instruction

f. Determination of those aspects of behavior which require feedback to promote optimal team performance

g. Identification of independent abilities and skill levels

h. Establishment of validity of proposed performance measures

i. Determination of interaction between proposed performance measures

j. Additions to existing performance measures and standards

k. Determination of additional information characteristics required to train each SFO.

EXHIBIT C-1

MARINER SKILLS VS TRAINING TECHNIQUES
AND FEEDBACK METHODOLOGIES

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Neumeric	Motion (relative/absolute)	Deepth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (inter.al feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm, one & two way	Textual	Obscured vision	State of the organization alterness/fatigue	Temporal discrete or intermittant	Spatial orientation & source of input	Redundancy (Regularit:
A. NAVIGATION																										
A-1 Visual Obtain visual indications of position so as to update knowledge of own ship's position in respect to charted course a) observe visually any outside activity	X	X	X	X			X	X	X	X	X	X					?		X		X	X		X	X	
b) scan & search surroundings waters with binoculars to: 1. recognize and evaluate contact 2. recognize navigational hazards and aids such as obstacles, shoals, buoy.	X	X	X	X			X	X	X	X	X	X			X		?		X		X	X		X	X	
Establish the visual range and bearing to navigational aids by using: a) azimuth circle - bearing *b) radar-range & bearing.		X	X	X	X	X		X	X	X	X								X	X	X	X		X		
A-2 Intended Track Study intended track: a) locate fixed navigational aids b) analyze the selection of proper course c) apply the effect of local wind and weather.	X	X	X	X	X	X	X	X	X	X	X								X	X	X	X		X	X	
Check for accuracy, the position plotted by the mate.		X		X	X	X					X	X	X									X				

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MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Numeric	Motion (relative/absolute)	Depth	Contrast	Brightness (intensity)	Temporal (continuous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm., one & two way	Textual	Obscured vision	State of the organization alertness/fatigue	Temporal discrete or intermittent	Spatial orientation - source of input	Redundancy (Regularity)
A-3 Navigation Orders and Safety Considerations																										
Convey navigation orders to other personnel.																										
Issue proper orders for safe navigation to: a) Helmsman b) Radar Operator c) Mate on Watch					X	X	X							X			X			X				X		X
A-4 Gyro Compass																										
Compare the readings of a magnetic compass and a gyro compass.																										
Calculate the difference between the two compass readings.																										
Correct the gyro compass.	X	X			X	X			X		X		X		X										X	X
A-5 Weather and Sea-State																										
Operate a radio facsimile recording system to obtain facsimile weather charts	X	X		X	X	X			X		X		X		X											
Read and interpret weather charts.	X	X		X	X	X			X		X															
Listen to weather broadcasts choosing the proper station.					X	X						X				X	X		X	X					X	
Decide whether or not to deviate from intended track on the basis of weather conditions												X	X							X				X	X	X

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Neumeric	Motion	Deepth (relative/absolute)	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory Frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm., one & two way / Textual	Obscured vision	State of the organization alterness/fatigue	Temporal discrete or intermittant	Spatial orientation & source of input	Redundancy (Regularity)
Monitor present weather and forecast future weather using own ship's a) barometer b) thermometer (wet and dry bulb) c) anemometer		X	X		X	X			X				X										X		X
Obtain set and drift information from: a) taffrail log b) navigation fixes c) Pilot charts	?	X	X	X	X	X	X		X	X			X	X		X	X		X	X			X	X	X
B. ELECTRONIC INDICATIONS OF POSITION Obtain electronic indications of position so as to update knowledge of own ship's position in respect to charted course using the following: *a) radar b) depth finder c) radio direction finder.	(a) X	X	X	(a) X	X	X	X	(a)	X	X	X	X	(a)(c) X	X	X	X	X		X				X	X	
B-1 Radar Operate a radar unit. Recognize the following navigational hazards and navigational aids on radar: a) obstacles b) buoys c) contacts d) landmarks e) shoals.	X		X	X	X	X	X		X	X	X	X	X	X	X				X	X	X			X	X

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Neumeric	Motion (relative/absolute)	Deepth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm., one & two way / Textual	Obscured vision	State of the organization alterness/fatigue	Temporal discrete or intermittant	Spatial orientation / Source of input	Redundancy (Regularit.
Evaluate range & bearing of a navigation hazard and/or navigational aid from radar unit.																									
Scan surrounding waters with radar for navigation hazard and aid detection; detect hazards and aids.																									
Inform Pilot and/or Mate on Watch of contact.																									
Monitor other or own ship's movements using radar.	X		X	X	X	X	X		X	X	X	X	X	X	X				X	X	X			X	X
Switch from relative to true vector on radar.																									
Switch from true to relative vector on radar.																									
Reflection plot on radar.																									
Erase reflection plots.																									
B-2 Depth Finder																									
Dtermine water depth by operating a depth finder.		X	X	X	X	X			X	X	X		X		X										
B-3 Radio Direction Finder Operate the radio direction finder to obtain a bearing.		X	X		X	X				X		X	X			X	X		X				X	X	X

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Numeric	Motion (relative/absolute)	Depth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm., one & two way Textual	Obscured vision	State of the organization alterness/fatigue	Temporal discrete or intermittent	Spatial orientation source of input	Redundancy (Regularity)
Plot RDF bearing on: a) Mercator Chart b) Lambert Chart.		X		X	X	X			X	X					X								X	X	
B-4 LORAN																									
Operate LORAN A & C equipment to obtain navigation data.																									
B-5 DECCA																									
Demonstrate ability to operate DECCA equipment.	X	X	X	*a X	X	X	X		X	X	X		X		X				X					X	X
B-6 NAVSAT																									
Operate NAVSAT equipment.																									
Demonstrate ability to read LORAN chart and tables.																									
Read and interpret NAVSAT tape readouts.	X	X	X.	X	X	X			X	X		X	*b X							X			X	X	
Plot LORAN data for two or three stations.																									
Plot NAVSAT data on charts.																									
Plot DECCA data from three stations.	X	X	X	X	X	X			X	X			*b X		X					X			X	X	X
Reset DECCA chain.	X	X	X		X	X				X	X													X	

*a) LORAN A & C NAVSAT
*b) NAVSAT

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Numeric	Motion (relative/absolute)	Depth	Contrast	Brightness (intensity)	Temporal (continuous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm, one & two way	Textual	Obscured vision	State of the organization alertness/fatigue	Temporal discrete or intermittent	Spatial orientation Source of input Redundancy (Regularity)
C. COMMUNICATION C-1 Internal Operate and monitor walkie talkie for: a) navigation b) watchstanders c) tug d) Pi'ot ship. C-2 External Operate and monitor VHF FM (voice radio): a) VTS b) ship-to-ship c) ship-to-shore d) Pilot ship e) emergency frequency. Monitor ship/ship and ship/lifeboat communications.		X			X	X						X	X	X	X	X	X		X	X			X	X	X
Order the Mate on Watch to: *a) initiate external signals (i.e., whistle, signal flags, navigation lights, anchor lights, shapes).	X	X	X	X						X				X		X	X		X	X	X				X
D. SHIP CHARACTERISTICS Receive ship readiness report from Master and act accordingly, as to: a) equipment status b) ship operating characteristics c) special information regarding ship indicators, communication and contro' systems, and alarms along with the	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Neumeric	Motion (relative/absolute)	Deepth	Contrast	Brightness (intensity)	Temporal (continuous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory Intensity (loudness)	Texture	Ambient Noise	Verbal Comm, one & two way	Textual	Obscured vision	State of the organization alertness/fatigue	Temporal discrete or intermittent	Spatial orientation, Source of input, Redundancy (Regulari:
location of each d) Ship's draft, trim, dimensions, "hog" and "sag" characteristics under existing ballast/laden conditions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
E. SHIP HANDLING																									
E-1 Change Course																									
Order personnel to operate EOT and set propeller RPM. Order the Helmsman to change course		X			X	X	X	X	X					X	X	X	X		X	X			X	X	X
E-2 Anchoring Order personnel to drop anchor.		X	X	X	X	X	X	X	X	X				X	X	X	X		X	X	X		X	X	X
E-3 Docking Issue commands to line handlers on pier. Issue orders to personnel on line to: a) tugs b) pier.		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
F. SHIP CONTROL/NON-SHIP-CONTROL EMERGENCIES Examine & evaluate total data input in accordance with the particular situation to determine: a) non-ship control emergency b) ship control emergency c) normal watchstanding routine.	X	X	X	X	X	X	X	X	X	X		X	X	X		X	X		X	X		X	X	X	X

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Numeric	Motion (relative/absolute)	Depth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm., one & two way	Textual	Obscured vision	State of the organization alertness/fatigue	Temporal discrete or intermittant	Spatial orientation source of input	Redundancy (Regula...
Decide the type of corrective action and the correct timing for such action in varying emergencies.											X	X		X					X	X				X	
Construct a personnel emergency bill outlining duties for each person.											X	X			X					X		X		X	
Monitor total operation of all personnel.	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X
F-1 Equipment Failures																									
Inspect mechanical & electrical equipment on broad the vessel.	X			X	X	X		X	X	X		X			X	X	X		X	X	X		X	X	
Evaluate the causes of certain equipment failures (See#67) and take corrective ship control action.					X	X	X				X	X				X	X		X	X					
Take corrective action to repair or replace failed equipment.	X	X		X	X	X		X	X	X	X	X			X	X	X		X	X	X			X	
F-2 Dial Indicators																									
Read the rudder angle indicator.	X	X	X	X	X	X			X	X	X									X				X	
Read & interpret the following: a) course & speed indicators and alarms b) turn rate indicator.	X	X	X		X	X			X	X	X					X	X			X				X	
Receive reports from bridge personnel regarding these indicators & take appropriate action.					X	X							X	X						X			X	X	X

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Neumeric	Motion (relative/absolute)	Deepth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm, one & two way	Textual	Obscured vision	State of the organization alertness/fatigue	Temporal discrete or intermittent	Spatial orientation; Source of input; Redundancy (Regular)
G. MAN OVERBOARD In a man overboard situation, conn the vessel to clear the man and remain in navigable waters: a) Order heading, rudder, and speed changes b) Maintain lee side c) Maintain navigable position.	X		X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X		X	
Transmit situation report on the of radio to: a) other ships b) Coast Guard shore facilities.		X			X	X				X	X			X		X	X		X	X			X		X
Conn the vessel to remain clear of other ship contacts in an emergency situation: a) Visually ascertain ship contact's course and speed b) Perform relative motion calculations c) Evaluate proper changes in own ship's motion d) Utilize radar to track contacts e) Make avoidance decisions in a timely manner		X	X	X	X	X	X	X	X	X	X		X			X	X		X	X				X	X
Order lookout to report the relative position of the man overboard.				X	X															X					

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Numeric	Motion (relative/absolute)	Depth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm., one & two way / Textual	Obscured vision	State of the organization alertness/fatique	Temporal discrete or intermittant	Spatial orientation / Source of input	Redundancy (Regular)
In emergency situations, maintain a navigation plot to: a) remain in navigable water b) avoid ship contacts c) provide SAR forces with location d) movement of other ships		X		X	X	X	X				X	X		X		X	X			X				X	X
In emergency situations maintain a navigational plot by: a) visual means b) electronic means c) dead reckoning.	X	X	X	X	X	X	X	X	X	X		X	X		X						X			X	X
Order man overboard party called away														X		X	X		X	X			X	X	
Designate proper lifeboats to be swung out, cleared, and lowered for appropriate emergency situations.	X				X	X	X	X								X	X			X		X	X	X	
Instruct boat officer on: a) location of man b) ship traffic c) weather conditions d) future ship movements e) weather & sea state.				X	X	X	X	X	X							X	X		X	X		X	X	X	X
Maneuver ship to facilitate lifeboat recovery: a) provide lee side b) avoid running down ship's boat or man c) avoid other ship contacts.		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X		X	X				X	

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Neumeric	Motion (relative/absolute)	Deepth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm., one & two way	Textual	Obscured vision	State of the organization alertness/fatigue	Temporal discrete or intermittant	Spatial orientation	Source of input	Redundancy (Regularity)
Recover man overboard party: a) monitor action by ship personnel in bringing boat alongside b) monitor securing & lifting of boat aboard ship c) provide medical care for rescued man.		X	X	X	X	X	X	X	X	X	X	X	X			X	X		X	X	X	X		X			
Conn the vessel to resume intended course and speed.		X	X	X	X	X	X				X			X		X	X		X	X				X			
I a man overboard situation, call away more lookouts to keep the man in sight.																				X			X	X	X		
Direct lifeboat in water via: a) radio b) Flashing lights c) Masthead lights d) Hand signals.		X	X	X	X	X		X	X	X	X		X	X	X(d)	X	X		X	X			X(b)	X			
H. FIRE ON BOARD																											
In a "Fire On Board" emergency, conn the vessel to: a) Remain in navigable waters b) Avoid other ship contacts c) Minimize wind and sea effect		X	X	X	X	X	X	X	X	X	X					X	X		X	X				X	X		
Order Fire Party called away.					X	X		X	X					X		X	X		X	X				X			
Evaluate location, nature, & extent of fire.	X		X	X	X	X		X	X	X	X					X	X			X	X			X	X		

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Neumeric	Notion (relative/absolute)	Deepth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm, one & two way	Textual	Obscured vision	State of the organization alterness/fatique.	Temporal discrete or intermittant	Spatial orientation	Source of input	Redundancy (Regular:
Conn the vessel to minimize fire damage.					X	X	X	X	X		X			X					X	X				X	X		
Monitor and direct fire fighting effots: a) order additional personnel b) order employment of proper equipment c) order the operation of fixed fire fighting systems d) order dewatering and ballasting as required e) order closure of watertight doors f) order tanks flooded to prevent spread of fire.	X	X	X	X	X	X		X	X	X	X			X		X	X		X	X				X	X		
Request external help via: a) Radio b) Flashing Light c) Signal flars & shapes.	(b, c) X	(b) X	(b, c) X	(c) X	X	X	X		X	(b, c) X	X			X		X	X			X				X	X		
Decide type and amount of assistance required from: a) other ships b) Tugs c) Coast Guard 1. air 2. surface					X	X					X	X	X											X	X		
Order jettisoning or offloading of cargo if necessary.																X	X		X	X				;			
Provide medical care as required.																				X		X		X			

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Neumeric	Motion (relative/absolute)	Deepth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise / Verbal Comm, one & two way	Textual	Obscured vision	State of the organization alterness/fatigue	Temporal discrete or intermittant	Spatial orientation & source of input	Redundancy (Regularity)
I. COLLISION AND/OR FLOODING																									
In time of emergency, decide whether to anchor or ground ship clear of the channe to prevent sinking or to control flooding	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X	X			X	X	
Anchor or ground ship clear of channel to prevent sinking or control flooding.	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X				X	X	
Execute "abandon ship" if required.				X	X	X	X			X					X	X			X		X		X	X	
Under emergency situations conn the VLCC to: a) minimize damage b) recover personnel c) remain clear of ship contacts d) anchor or ground vessel if necessary e) clear channel.	X)	X)	X	X	X	X	X	X	X	X	X		X		X	X		X	X	X			X	X	
Order damage control party called away.										X			X		X	X		X	X		X		X	X	
Evaluate extent of damage of own or other vessel.	X	X	X	X	X		X	X	X	X	X	X	X						X				X	X	
commend maneuvers to Pilot to minimize flooding.	X	X	X	X	X	X	X	X	X	X			X		X	X		X	X				X	X	

MARINER SKILLS VS TRAINING TECHNIQUES AND FEEDBACK METHODOLOGIES

SKILLS	Color (hue)	Black & White (saturation)	Size of image (visual angle)	Shape Form (graphic/picture)	Alphabetic	Numeric	Motion (relative/absolute)	Deepth	Contrast	Brightness (intensity)	Temporal (continous)	Random (irrelevant information)	Distortion of (information input)	Rate of Presentation	Proprioceptive (internal feedback)	Auditory frequency (pitch)	Auditory intensity (loudness)	Texture	Ambient Noise	Verbal Comm. one & two way	Textual	Obscured vision	State of the organization alterness/fatigue	Temporal discrete or intermittant	Spatial orientation & source of input	Redundancy (Regular)
Monitor and direct Damage Control Party: a) order additional personnel to scene b) order employment of proper equipment c) order closing of watertight doors d) order dewatering of flooded or tanks e) order counterballasting as necessary.	X	X	X	X	X		X	X	X	X			X		X	X		X	X					X	X	
Receive reports from bridge personnel.											X		X		X	X		X	X					X	X	

EXHIBIT C-2

TABULATION OF MARINER SKILLS BY
BASIC INFORMATION CHARACTERISTICS

TABULATION OF MARINER SKILLS BY BASIC INFORMATION CHARACTERISTICS

The following matrix correlates skills required for proficient seamanship and the basic information characteristics which would require consideration in developing a training system for each skill. The matrix should be read as follows:

a. Select the skill for which training is to be specified.

b. Read across columns of information characteristics making note of all cells for that skill which contain a check under the information characteristics columns.

c. Compile those information characteristics specified for training the particular skill of interest.

d. In developing the training program, incorporate all those information characteristics specified.

Although many of these information characteristics are necessary for training of specific skills, the degree of emphasis required has not been determined.

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
A. NAVIGATION A-1 Visual Obtain visual indications of position so as to update knowledge of own ship's position in respect to charged course a) observe visually any outside activity	X			X			X										
b) scan & search surrounding waters with binoculars to: 1. recognize and evaluate contact 2. recognize navigational hazards and aids such as obstacles, shoals, buoy.	X	X		X			X						X				
Establish the visual range and bearing to navigational aids by using: a) azimuth circle - hearing *b) radar-range & bearing	X					X	X					X	X				
A-2 Intended Track Study intended track: a) locate fixed navigational aids b) analyze the selection of proper course c) apply the effect of local wind and weather	X					X	X			X	X		X				X
Check for accuracy, the position plotted by the mate	X					X		X									

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
A-3 Navigation Orders and Safety Considerations																	
Convey navigation orders to other personnel. Issue proper orders for safe navigation to: a) Helmsman b) Radar Operator c) Mate on Watch	X					X		X	X				X		X	X	
A-4 Gyro Compass																	
Compare the readings of a magnetic compass and a gyro compass. Calculate the difference between the two compass readings. Correct the gyro compass.	X					X	X			X		X	X				X
A-5 Weather and Sea-State																	
Operate a radio facsimile recording system to obtain facsimile weather charts		X				X	X			X		X	X			X	X
Read and interpret weather charts.	X			X			X				X		X				
Listen to weather broadcasts choosing the proper station	X		X										X				X
Decide whether or not to deviate from intended tract on the basis of weather conditions	X			X			X		X	X	X	X				X	X

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
Monitor present weather and forecast future weather using own ship's a) barometer b) thermometer (wet and dry bulb) c) anemometer	X					X	X		X	X			X			X	
Obtain set and drift information from: a) taffrail log b) navigation fixes c) Pilot charts	X			X			X		X	X	X		X			X	X
B. ELECTRONIC INDICATIONS OF POSITION Obtain electronic indications of position so as to update knowledge of own ship's position in respect to charted course using the following: *a) radar b) depth finder c) radio direction finder	X					X	X			X	X	X	X			X	X
B-1 Radar Operate a radar unit. Recognize the following navigational hazards and navigational aids on radar: a) obstacles b) buoys c) contacts d) landmarks e) shoals.	X	X		X			X						X	X			

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
Evaluate range & bearing of a navigation hazard and/or navigational aid from radar unit.	X	X				X	X						X				
Scan surrounding waters with radar for navigation hazard and aid detection: detect hazards and aids	X					X	X			X			X	X			
Inform Pilot and/or Mate on Watch of contact.	X		X					X									
Monitor other or own ship's movements using radar.	X		X				X		X	X	X					X	X
Switch from relative to true vector on radar			X				X					X					
Switch from true to relative vector on radar			X				X					X					
Reflection plot on radar.																	
Erase reflection plots.			X				X					X					
B-2 Depth Finder																	
Determine water depth by operating a depth finder	X		X				X						X	X			
B-3 Radio Direction Finder																	
Operate the radio direction finder to obtain a bearing	X		X				X					X		X			

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
Plot RDF bearing on: a) Mercator Chart b) Lambert Chart		X	X				X						X				
B-4 LORAN																	
Operate LORAN A & C Equipment to obtain navigation data.		X				X	X						X				X
B-5 DECCA																	
Demonstrate ability to operate DECCA equipment.		X				X	X						X				X
B-6 NAVSAT																	
Operate NAVSAT equipment.		X				X	X						X				X
Demonstrate ability to read LORAN chart and tables		X		X			X				X		X			X	X
Read and interpret NAVSAT tape readouts.	X	X		X			X				X		X			X	X
Plot LORAN data for two or three stations.	X	X		X			X				X		X			X	X
Plot NAVSAT data on charts.	X	X				X	X				X	X	X				
Plot DECCA data from three stations.	X	X				X											
Reset DECCA chain.																	
*a) LORAN A & C NAVSAT *b) NAVSAT		X				X	X						X				

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
C. COMMUNICATION																	
C-1 Internal																	
Operate and monitor walkie talkie for: a) navigation b) watchstanders c) tug d) Pilot ship.	X	X	X					X				X	X		X	X	X
C-2 External																	
Operate and monitor VHF FM (voice radio): a) VTS b) ship-to-ship c) ship-to-shore d) Pilot ship e) emergency frequency	X	X	X				X					X	X				
Monitor ship/ship and ship/lifeboat communications	X	X	X				X					X	X				
Order the Mate on Watch to: *a) initiate external signals (i.e., whistle, signal flags, navigation lights, anchor lights, shapes).	X	X		X				X					X		X		X
D. SHIP CHARACTERISTICS																	
Receive ship readiness report from Master and act accordingly, as to: a) equipment status b) ship operating characteristics c) special information regarding ship indicators, communication and control systems, and alarms along with the location of each	X	X		X				X		X			X				X

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
D) Ship's draft, trim, dimensions, "hog" and "sag" characteristics under existing ballast/laden conditions	X	X		X				X		X			X			X	X
E. SHIP HANDLING																	
E-1 Change Course																	
Order personnel to operate EOT and set propeller RPM.		X	X					X					X		X		
Order the Helmsman to change course.		X	X					X					X		X		X
E-2 Anchoring																	
Order personnel to drop anchor.		X	X					X					X		X		X
E-3 Docking																	
Issue commands to line handlers on pier. Issue orders to personnel on line to: a) tugs b) pier	X	X		X				X	X	X	X		X		X	X	X
F. SHIP CONTROL/NON-SHIP-CONTROL EMERGENCIES																	
Examine & evaluate total data input in accordance with the particular situation to determine: a) non-ship control emergency b) ship control emergency c) normal watchstanding routine	X	X				X		X		X		X	X				X

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
Decide the type of corrective action and the correct timing for such action in varying emergencies.	X			X				X	X	X	X		X		X	X	X
Construct a personnel emergency bill outlining duties for each person.	X		X			X	X						X				
Monitor total operation of all personnel	X			X				X		X			X		X	X	X
F-1 Equipment Failures																	
Inspect mechanical & electric equipment on board the vessel	X			X			X			X			X				X
Evaluate the causes of certain equipment failures and take corrective ship control action.	X	X		X			X		X				X				X
Take corrective action to repair or replace failed equipment	X	X		X				X		X			X				X
F-2 Dial Indicators																	
Read the rudder angle indicator.		X	X				X						X	X			
Read & interpret the following: a) course & speed indicators and alarms b) turn rate indicator.		X	X				X						X	X			
Receive reports from bridge personnel regarding these indicators and take appropriate action.	X			X				X	X	X					X	X	

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
G. MAN OVERBOARD In a man overboard situation, conn the vessel to clear the man and remain in navigable waters: a) Order heading, rudder, and speed changes b) Maintain lee side c) Maintain navigable position.	X	X				X		X	X	X	X		X		X	X	X
Transmit situation report on the radio to: a) Other Ships b) Coast Guard shore facilities		X	X				X						X		X		X
Conn the vessel to remain clear of other ship contacts in an emergency situation: a) Visually ascertain ship contact's course and speed b) Perform relative motion calculations c) Evaluate proper changes in own ship's motion d) Utilize radar to track contacts d) Make avoidance decisions in a timely manner.	X	X		X				X	X	X	X	X	X		X	X	X
Order lookout to report the relative position of the man overboard.		X	X					X				X	X		X		X

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
In emergency situations, maintain a navigation plot to: a) remain in navigable water b) avoid ship contacts c) provide SAR forces with location d) movement of other ships	X	X		X				X		X			X		X	X	X
In emergency situations maintain a navigational plot by: a) visual means b) electronic means c) dead reckoning	X	X		X			X			X			X		X	X	X
Order man overboard party called away	X	X				X		X					X		X		X
Designate proper lifeboats to be swung out, cleared, and lowered for appropriate emergency situations.	X	X				X							X		X	X	X
Instruct boat officer on: a) location of man b) ship traffic c) weather conditions d) future ship movements e) weather & sea state	X	X		X				X							X	X	X
Maneuver ship to facilitate lifeboat recovery: a) provide lee side b) avoid running down ship's boat or man c) avoid other ship contacts.																	

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
Recover man overboard party: a) monitor action by ship personnel in bringing boat alongside b) monitor securing & lifting of boat aboard ship c) provide medical care for rescued man.		X		X				X					X		X		X
Conn the vessel to resume intended course and speed.	X					X		X					X				
In a man overboard situation, call away more lookouts to keep the man in sight.		X				X		X					X		X		X
Direct lifeboat in water via: a) Radio b) Flashing lights c) Masthead lights d) Hand signals		X		X				X				X	X		X		X
H. FIRE ON BOARD In a "Fire On Board" emergency, conn the vessel to: a) Remain in navigable waters b) Avoid other ship contacts c) Minimize wind and sea effect.	X	X		X				X	X	X	X		X		X	X	X
Order Fire Party called away.		X				X							X				
Evaluate location, nature & extent of fire	X			X				X		X			X			X	X

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
Conn the vessel to minimize fire damage. Monitor and direct fire fighting efforts: a) order additional personnel b) order employment of proper equipment c) order the operation of fixed fire fighting systems d) order dewatering and ballasting as required e) order closure of watertight doors f) order tanks flooded to prevent spread of fire	X	X		X				X					X		X	X	X
Request external help via: a) Radio b) Flashing Light c) Signal flags & shapes.		X	X				X						X				
Decide type and amount of assistance required from: a) Other ships b) Tugs c) Coast Guard 1. air 2. surface	X	X		X				X		X					X	X	X
Order jettisoning or offloading of cargo if necessary.		X				X		X					X		X		X
Provide medical care as required.	X			X				X		X					X	X	X

MARINER SKILLS VS INFORMATION CHARACTERISTICS

SKILLS	General	Specific	Pure Part Task	Progressive Part Task	Simplified Training	Whole Task	Individual Training	Team Training	Prediction Training	Adaptive Training	Student Generated Elaboration	Intrinsic	Extrinsic (Positive/Negative)	Augmented Feedback	Timeliness of Feedback	Positive Guidance	Action Feedback
I. COLLISION AND/OR FLOODING In time of emergency, decide whether to anchor or ground ship clear of the channel to prevent sinking or to control flooding.	X			X			X		X	X	X		X		X	X	X
Anchor or ground ship clear of channel to prevent sinking or control flooding.		X		X			X		X				X				X
Execute "abandon ship" if required.	X					X	X						X			X	
Under emergency situations conn the VLCC to: a) minimize damage b) recover personnel c) remain clear of ship contacts d) anchor or ground vessel if necessary e) clear channel.	X	X		X				X	X	X			X		X	X	X
Order damage control party called away.	X					X		X								X	
Evaluate extent of damage of own or other vessel.	X			X				X					X		X	X	
Command maneuvers to Pilot to minimize flooding.	X					X		X		X			X		X		X
Monitor and direct Damage Control Party: a) order additional personnel to scene b) order employment of proper equipment c) order closing of watertight doors d) order dewatering of flooded tanks e) order counterballasting as necessary.	X			X				X		X	X		X		X	X	X
Receive reports from bridge personnel	X					X						X			X		

EXHIBIT C-3

PERFORMANCE MEASURES AND STANDARDS

PERFORMANCE MEASURES AND STANDARDS

1. Selection of proper speed to minimize squat, cushion, drag and suction.

2. Swept path.

3. Forward/aft velocity = 1 or 1

4. $\frac{\text{Max Rudder - Average Rudder}}{\text{Max Rudder}}$ = Available Rudder

5. Deviation off track "d".

6. Deviation off track relative to channel boundary 'd/D'.

7. Time to detect squat cushion and suction effects.

8. Time to take corrective action to overcome or take advantage of the squat, suction and cushion = Time to Equilibrium.

9. Cognitive workload.

10. Time to detect effects due to wind and current.

11. Time to compensate or take advantage of the effect of winds and current = Time to Equilibrium.

12. $\frac{\text{Max rpm - Average rpm}}{\text{Max rpm}}$ = Available Propulsion

13. Accuracy of position determination.

14. Make VHF security call.

15. Under keel clearance.

16. Target detection time.

17. Sound proper whistle signals.

18. Determine target's range, bearing, speed, and course.

19. Accuracy of position determination from visual cross bearings using known land masses.

20. Time to establish fix given navigation aids available.

21. Time to establish course given range markers (lineup).

22. Time to determine fault in navigational aids.

23. Overshoot/undershoot = Area under the curve formed by ship trajectory and reference track from a point 1/2 mile before apex of turn and 1/2

mile after apex of turn relative to absolute area of channel on either side of the reference track bounded by the shoal line.

24. Point of initiation of turn.

25. Speed at initiation of turn.

26. Average rudder used in turn area.

27. Time to re-align vessel on reference track after pull from turn.

28. Bridge-to-Lookout communications.

29. Accuracy of navigational plot maintained.

30. Angle of intersection of ship trajectory and reference track.

31. Number of intersections of reference track.

32. Horizontal clearance.

33. Vertical clearance.

34. Time to select and identify navigational aids to be employed for position determination.

35. Time to determine where masked or misplaced navigation aids should be located.

36. Swept path through turn area relative to available area in turn.

37. Proper utilization of CAS
    (a) Trail bearing and trial speed
    (b) Selection of adequate CPA
    (c) Ability to maintain CPA desired

38. Radar plotting
    (a) Plot relative motion lines and speed triangles for vessels simultaneously
    (b) Determine CPA of each vessel
    (c) Determine target course $\pm 5^{\circ}$ at 10 miles
        $\pm 1^{\circ}$ at 5 miles
        within fixed period of time (2 minutes)
    (d) Time to determine result of a trial maneuver on the radar relative to other target vessels.
    (e) Target speed ± 2 knots at 10 miles
        ± 0.5 knots at 5 miles
        within 3 minutes

(f) Target bearing error $\pm 2^{o}$ at 20 miles

$\pm 1^{o}$ at 10 miles

$\pm 1/2^{o}$ at 5 miles

(g) Determine time to CPA ± 2 minutes within 6-minute time interval

39. Accuracy of position when anchor is dropped.

40. Velocity when anchor drops or when approaching dock or mooring.

41. Drift after anchor drops or after lines are made fast to dock or mooring.

42. Swing after anchor drops or after lines are made fast to dock or mooring.

43. Time and accuracy to locate turn position bearings in order to proceed.

44. Observe and determine the swing area of other ships.

45. Observe cargo state: loaded, ballast, etc.

46. Determine size of other vessels.

47. Determine amount of anchor slippage.

48. Accuracy of position relative to other ships.

49. Frequency of anchor bearings.

50. Determine position of obstruction relative to own ship.

51. RPM

52. Where trainee wants to be (projected position) vs where he actually is.

53. What trainee expects vs what actually develops.

54. Position from other objects, obstructions, and/or ships.

55. Time to stop vessel.

56. Engine response time.

57. Rate of turn relative to headway.

58. Time to execute the desired maneuver.

59. Maintain position within traffic lane (time out of traffic lane/time in traffic lane).

60. Determine if any gyro error exists and make appropriate compensation.

61. Select proper VHF channel and functioning of VHF.

62. Determine any error in radar.
    (a) Heading flasher
    (b) Range scale
    (c) Course and heading repeater

63. Check engine telegraph.

64. Check rudder reaction, rudder response time, and rate of turn.

65. Determine draft fore and aft.

66. Be familiar with hull configuration.

67. If twin screw, determine distance between screws.

68. What is ship traffic in the vicinity.

69. What is nearest aid to determine position.

70. What are capabilities of tug boats.

71. Lateral velocity of vessel.

72. What ships will be more subject to wind and current relative to own ship.

73. Know what is happening ahead via VHF with other vessels in vicinity.

74. Stress or state of arousal.

75. Determine freeboard.

76. Efficiency (slippage): engine speed relative to ship speed.

EXHIBIT C-4

TABULATION OF SFO'S BY PERFORMANCE MEASURES

TABULATION OF SFO'S BY PERFORMANCE MEASURES

The following matrix provides a listing of Specific Functional Objectives (SFOs) that have been derived from an exhaustive task analysis of shiphandling skills. The column adjacent to the SFO column contains coded listings of all performance measures that will be recorded to determine the relative proficiency of the trainee's shiphandling capabilities, and any change in performance over the course of training. The sensitivity of some measures in terms of reliability and objectivity has been established from prior research and measurement analysis, while that of others has not been empirically validated. A primary objective of Phase II is to establish the validity of these proposed performance measures.

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
I. FUNDAMENTAL SHIP HANDLING	
A. Ship-Environmental Effects	
Maneuver the vessel holding course and heading under steady state and varying environmental conditions: 1. Wind speeds of 0-50 KTS (any direction). 2. Current speeds of 0-3 KTS (any direction). 3. Tide heights of 1-20 FT (ebb, neap). 4. Sea state of 0-9. 5. Any combination of # 1- # 4.	#6,7,8,9,11,13,15,53,74. 2.
B. Ship Characteristics	
1. Understand and apply the following to ship maneuvering situations: (a) Range of RPM (b) RPM change time delay, including forward to reverse (c) RPM change rate over time	#53,55,56,63,50.
2. Understand and apply the effect of the following on stopping distance, time and position: (a) Effect of draft (b) Effect of freeboard (c) Effect of block coefficient (d) RPM factors (e.g., engine time to reverse) (e) Rudder factors (e.g., deceleration in turn) (f) Deceleration tables	#7,8,10,11,20,24,26,36, 25, 51,53,55,56,57,63,64,65, 66,67,75,76.
3. Stop the vessel predicting its time-dependent path, considering various displacements, speeds, astern RPM and engine time to reverse, using each of the following techniques:	

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
(a) Rudder cycling (b) Coasting stop (c) Full engine reverse (d) J stopping maneuver (e) Crash stop (f) Other stopping devices such as variable pitch propeller, twin screw, and rotatable propeller.	#2,52,53,55,59,58,64,63, 66,65,67 .
C. Hydrodynamic Effects	
1. Compensate for or take advantage of the effect of suction between ships as well as between own ship's quarter and the shallower water at the edge of the fairway when:	
(a) Maneuvering around docks (b) Maneuvering in confined waters (c) Meeting or passing another vessel in a confined channel	#7,8,10,11,13,52,53,54, 58,68 .
2. Compensate for or take advantage of bank effects when maneuvering through the channel.	#4,7,8,13,15,54,64,76
D. Maneuver Techniques	
1. Execute a zig-zag (Kempf) maneuver, projecting own ship's track:	
(a) At a speed of 15 KT in the Open Sea prior to maneuver (b) Using no greater than a 20° rudder angle.	#10,11,13,52,53,57,58,64.
2. Execute a spiral maneuver, projecting own ships track:	

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
(a) At a speed of 15 KT in the Open Sea, prior to the maneuver (b) Begin by putting over a 15° starboard rudder	#10,11,13,24,25,51,52,55, 56,57,75.
3. Execute a Williamson turn so as to pick up a man over-board in reduced visibility.	#10,11,13,24,25,28,52,54, 51,57,58,64,69,75.
4. Maneuver the vessel through the channel under high wind conditions, using the kick effect to assist in maintaining own ship's position within the channel.	#1,7,8,10,11,13,15,51,53, 57,64,65,75.
5. Plan and carry out when to initiate a turn by determining the amount of rudder, the use of RPM, and other operations (e.g., kick effect) along with the correct timing for implementation.	#1,2,8,11,13,19,20,21,23, 24,25,26,27,36,43,51,52,53, 54,56,57,58,64,69,73 .
E. Rules of the Road	
1. Detect and interpret ship traffic for required collision avoidance actions when own ship is the stand-on vessel and the following situtation exists:	
(a) Head-on (b) Overtaking (c) Crossing	#8,9,11,13,14,16,18,20,37, 38,51,52,53,54,62 .
2. Detect and interpret ship traffic for required collision avoidance actions when own ship is the give-way vessel and the following situation exists:	
(a) Head-on (b) Overtaking (c) Crossing	#8,9,11,13,14,16,18,20,37, 38,48,51,52,53,54,58,59, 62,73 .

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
II. INTEGRATED SHIP HANDLING	
A. Port Entry	
Navigate the vessel through the waterway plotting own ship's position with data obtained from:	
1. Develop port entry, channel navigation, and docking plan with alternatives. Then execute the plan with the necessary alterations: 2. Decca 3. Loran 4. RDF 5. Visual fixes 6. Radar	#1,2,8,10,11,13,14,17, 19,20,24,25,28,29,34, 35,48,50,51,52,53,54, 55,56,57,58,59,60,61, 63,64,65,66,68,69,70, 7,71,73.
7. Navigate through the waterway, operating a depth finder to determine water depth and assist in fixing own ship's position.	#7,8,13,14,15,20.
8. Navigate through the waterway, operating a radar unit to aid in the detection of navigational hazards and aids	#13,20,22,29,34,35,62,73.
9. Maneuver the vessel through the waterway, communicating via ship-to-ship, using the proper VHF frequencies, exhibiting proper terminology and procedures so as to avoid collisions.	
10. Communicate with the pilot boat or with tugs for planning purposes when entering the port, exhibiting proper terminology and procedures.	
11. Communicate via ship-to-shore to determine docking location and have docking preparation initiated.	

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
12. Send/receive communication from the pilot as to "what side of the ladder" and weather at the station, using the appropriate terminology and procedures.	#10,11,13,18,37,38(d),43, 51,52,53,54,55,56,57,58, 63,64,73.
13. Maneuver the vessel to come to slow and decide whether to turn to right or left for lee to pick up/drop off a pilot.	
14. Approach the channel, entering the appropriate traffic separation schemes when varying traffic density and various types of ships are present.	#10,11,13,14,16,28,34,37, 38,45,46,59,60,61,62,63, 18,64,65,68,72,73.

B. Restricted Waterway/Channel Navigation and Ship Handling

Maneuver the vessel through the channel when the channel is restricted in width and depth relative to the ship's beam and draft.

1. Maneuver the vessel through port and starboard turns in a channel, changing ship's speed as necessary and using a bow thruster when the channel bends are: (a) Greater than 90^{o} (b) 60^{o} - 90^{o} (c) Less than 60^{o}	#1,2,3,6,7,8,10,11,13,14, 15,19,20,23,24,25,27,36, 51,52,53,54,56,57,58,63, 64,67,71,73,76.
2. Maneuver the vessel under a bridge structure using appropriate planning techniques (e.g., studying charts and publications). The following bridge conditions should exist.	

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
(a) Satisfactory horizontal and vertical clearance	
(b) Satisfactory vertical clearance but horizontal clearance is constrained by bridge support structures.	#1,10,11,13,14,17,19,20,28, 32,33,34,50,51,52,53,54,56, 57,58,63,64,71,73.
(c) Bridge is lighted	
(d) Bridge is unlighted	
3. Time the maneuver for the opening of the bridge during different stages of approach when:	
(a) Opening time communicated is correct (b) Opening time communicated is delayed	#1,10,11,13,14,17,19,20,28, 32,33,34,50,51,52,53,54,55, 56,57,58,63,64,71,73.
4. Maneuver the vessel to remain on the intended track, when approaching and maneuvering into:	
(a) 2 cross channels	#1,2,5,6,10,11,13,14,19,20, 21,28,30,31,51,52,54.
(b) 3 or more cross channels	#59,69,73.
(c) "Y" channel (junction)	#1,2,5,6,10,11,13,14,19,20, 21,28,30,31,51,52,54,24,25,26, 27,36,43,57,58,63.64.
5. Execute a starboard and a port turn into crossing and " Y" channels, projecting own ship's track.	#1,2,5,6,10,11,13,14,19,20,21,28, 30,31,51,52,54,59,69,73,78,24,25, 26,27,36,43,57,58,63,64
6. Maneuver the vessel through a blind turn (i.e., visual and/or radar detection obstruction) in a channel when:	

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
(a) Other ship contacts are obscured by hills, trees, natural barriers, and manmade structures (b) Navigational aids are hidden until turn begins. (c) Oncoming vessel creates a meeting situation	#2,7,8,10,11,13,14,16,17, 18,19,34,35,36,37,43,48, 53,54,55,56,57,58,59,61, 68,72,73.
7. Maneuver the vessel in the channel and through various turns when forward vision is partially obstructed by ship structure or cargo (e.g., deck load stacking).	#2,7,8,10,11,13,14,16,17, 18,19,34,35,36,37,38,43, 48,53,54,55,56,57,58,59, 61,68,72,73.
8. Conn the vessel through the channel with consideration for the following nearby obstacles; located at various positions within the channel:	
(a) Dredges (b) Ships anchored adjacent to or in the channel (c) Numerous small craft, sailboats, fishing , etc. (d) Vessels in tow (e) Buoy tenders (f) Work under construction (g) Ship not under command (h) Cables and pipelines (i) Breakwater	#10,11,13,14,16,17,18,19, 28,32,37,38,44,45,46,48, 50,51,52,54,56,61,63,64, 65,68,72,73.
9. Maneuver the vessel to avoid a shoal or a wreck in the vicinity of the channel entrance when:	
(a) Marked by a buoy and/or (b) Fathometer is inoperative and/or (c) Possible shoaling due to recent storm	#1,7,8,10,11,13,14,15,17, 19,28,34,37,38(f),45,50, 51,52,53,56,57,61,68,71,73.

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
10. Maneuver the vessel through the ice, plotting continuous position	# 13,19,20,28,29,34,48,51, 53,56,57,62,63,64,66,68, 70,73.
11. Maneuver the vessel to avoid navigating through ice.	#10,11,13,19,34,37,38(f),52 58,61,62,50.
12. Maneuver the vessel through the channel without deviating from the intended track, when the navigational range structures available for various channel legs have:	
(a) A light extinguished; or (b) One or both range structures obscured; or (c) One structure missing	#7,8,9,10,11,13,19,20,21, 22,28,29,34,35,38(f),51, 52,56,57,60,69,74
13. Maneuver the vessel through the channel when navigational aids available for various legs of the channel are:	
(a) Extinguished (b) Off position (c) Missing	#7,8,9,10,11,13,19,20,21, 22,28,29,34,35,38(f),51, 52,56,57,60,69,74.
14. Maneuver the vessel through the channel when natural fixed or navigational structures are:	
(a) Masked (b) Missing	#7,8,9,10,11,13,19,20,21, 22,28,29,34,35,38(f),51, 52,56,57,60,69,74.
15. Maneuver the vessel into/out of channel when a ship is anchored in the approach to the sea buoy and the radar reference sea buoy is off location.	#10,11,13,14,16,18,19,20, 22,28,34,37,38,43,52,53, 61,62,69,74.
16. Communicate via ship-to-tugs using appropriate format and terminology to request tug assistance for channel maneuvering.	

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
17. Coordinate strategy to be used by tugs. Then communicate with the tugs as to the number of tugs needed and the placement of each.	#61,70.
18. Configure the vessel to facilitate tug assistance (e.g., ship speed). Coordinate vessel actions (e.g., rudder, RPM) with tug efforts to achieve objectives for normal situations.	#10,11,13,14,15,17,19,28, 34,45,48,51,52,53,55,56, 58,61,63,64,65,67,70,71.
C. Approach a Single Point Mooring	
1. Determine the ~~approach~~ bearings and the points at which to reduce speed and/or stop engines.	#10,11,13,19,27,28,34,40, 43,48,51,55,56,57,63,64, 69,71,67.
2. Maneuver the vessel in the approach to the mooring coordinating approach bearings and speeds, safely avoiding other traffic and other moored vessels.	#10,11,13,19,20,27,28,34, 37,38,40,43,44,45,46,48, 51,52,54,55,56,57,58,63, 64,68,71,72,75,67.
D. Approach a Dock	
1. Determine the approach bearings and the points at which to reduce speed and/or stop engines, with tug assistance.	#10,11,13,19,20,27,28,34, 40,43,51,52, 55,56,57,58, 61,63,64,67,70,71,73.
2. Maneuver the vessel, with tug assistance, in the approach to the dock coordinating approach bearings and speeds, safely avoiding other ship traffic.	#10,11,13,19,20,27,28,34, 40,43,51,52,55,56,57,58, 61,63,64,67,70,71,73,14,37, 38.
E. Approach an Anchorage	

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
1. Select the appropriate courses and navigational aids to fix the ship's position en route to the appropriate anchorage, check the depth of the water at the anchorage and locate the turning bearing.	#10,11,13,14,15,19,27,28, 34,36,43,51,55,56,57,58, 61,63,64,69.
2. Maneuver the vessel to approach the anchorage position, taking into account the locations of other anchored vessels. Accomplish this maneuver under the previously determined conditions as well as under the following conditions:	
a. Water depths of 100 - 500 ' b. Various types of holding ground c. One anchor/two anchors d. Having way on/ having no way on e. Using remote sensors and pilot house control	#10, 11,13,14,15,19,20,27, 34,37,38(f),44,43,45,46,47, 51,53,54,55,56,57,58,61,63, 64,65,68,71,72,73.
3. Anchor the vessel. Once anchored, take cross bearings to fix position.	#15,19,28,34,38(f), 39,40, 41,42,44,45,47,48,49,53,54, 58,61,65.

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
III. EMERGENCIES	
For emergency situations, the following conditions should be addressed in addition to the previously denoted conditions: A. Varying duration of failure B. Ship Configuration 1. Twin Screw 2. Single Screw 3. Controllable pitch propeller. C. Various time lags for power response.	
1. Plan for emergency action alternatives prior to entering the harbor, based on the identification of relevant harbor characteristics. Carry out plans under the various harbor situations.	#13,14,17,19,20,22,28,34, 35,50,55,56,63,64,65,68, 70,73,74,75.
2. Anchor or ground the vessel clear of the channel to minimize casualty damage due to: (a) Loss of power (b) Loss of steering (c) Collision (d) Fire	#13,14,15,17,19,28,32,39, 40,45,51,55,56,57,61,63, 64,65,67,69,70,73,74.
3. Maneuver the vessel through the channel maintaining ship control as best as possible when each of the following types of rudder failures occur: (a) Loose rudder (b) Rudder jamming of mechanical systems (c) Partial loss of rudder	#14,15,17,28,40,41,42,45, 55,56,57,59,61,63,64,65, 67,70,71,73,74.

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
4. Safely maneuver the vessel when there is a degradation in the amount of power available, including complete power failure.	#14,17,28,32,40,42,47,51, 53,55,64,65,70,73,74.
5. Maneuver the vessel through the channel when an electrical failure affecting ship control occurs in the following equipment.	
(a) Rudder angle indicator (b) Radar (poor visibility) (c) Gyro (d) Engine order telegraph.	#2,7,8,10,11,13,14,15,17, 22,28,34,37,38,43,51,55, 56,57,60,61,62,63,64,69, 73.
6. Utilize tug assistance when a casualty (e.g., power and/or steering failure) occurs while underway to:	
(a) Moor or dock (b) Anchor (c) Otherwise assist in maintaining vessel safety.	#14,15,17,28,54,61,70,73.
7. Safely maneuver the vessel through the channel when each of the following types of communication are required but are inoperative:	
(a) VHF	#1,2,7,8,10,11,13,15,17,19, 20,22,28,37,38,51,53,55,56 57.

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
(b) Whistle	#14,61,73,1,2,10,11,13,16, 18,19,20,22,28,34,46,51,53, 55,56,57,63,64,68.
(c) Running lights	# 1,2,10,11,13,14,16,17,18, 19,20,22,28,34,46,51,53,55, 56,57,61,63,64,68,73.
(d) Walkie-talkies	#1,2,10,11,13,14,16,17,18, 19,20,22,34,46,51,53,55, 56,57,61,63,64,68,73.
(e) Internal phone systems	#1,2,10,11,13,14,16,17,18, 19,20,22,34,46,51,53,55, 56,57,61,63,64,68,73.
8. Maneuver the vessel avoiding any collisions when the following equipment are inoperative:	
(a) Radar	#1,2,10,11,13,14,16,17,18, 19,20,22,28,34,46,51,53,55, 56,57,61,63,64,68,73.
(b) CAS	#1,2,10,11,13,14,16,17,18, 19,20,22,28,34,46,51,53,55, 56,57,61,63,64,68,73,38.
9. Configure the vessel to facilitate tug assistance (e.g.,ship speed). Coordinate vessel actions (e.g., rudder, RPM) with tug efforts to achieve objectives for emergency situations.	#10.11.14,15,17,28,51,52, 55,56,57,61,63,64,65,66, 70,71,73.

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
10. Maneuver the vessel through turns in the channel when:	
(a) A rudder failure occurs	#7,8,10,11,14,15,17,20,28, 36,40,41,42,43,47,51,55,56, 61,63,64,67,73.
(b) An engine failure occurs	#7,8,10,11,14,15,17,20,28, 36,40,41,42,43,47,55,57,61, 63,64,73.

SPECIFIC FUNCTIONAL OBJECTIVES	PERFORMANCE MEASURES
IV. BRIDGE PROCEDURES	
1. Research tidal information, check charted characteristics of navigation lights and buoys against lists of lights and navigation bulletins, consider the ship's maneuvering characteristics, and check prevailing conditions; then organize port entry/ port exit passage plans (preferred and alternate tracks) in detail so as to provide for full control of navigation. Organize the duties and pattern of communications of a bridge team so that the plan, once made, will be executed properly; especially when the unexpected arises. Include alternative action contingencies for the development of unexpected situations.	#52,53.
2. Execute the plans during passages, incorporating alternatives as necessitated by situation development.	#52,53.

APPENDIX D

TRAINING PROGRAM

D.1 INTRODUCTION

This appendix addresses the development of the training program which consists of the:

a. Training program structure — macro-level training framework consisting of the courses, their content and part- and whole-task simulators

b. Training process strategy — detailed training methodology pertaining to the mix of classroom and simulator training, exercise design, timing and content of feedback provided during training, and trainee input and output characteristics

c. Training support material — handout documents, scenarios, and feedback displays and charts

d. Instructor personnel

The training program will be based on information drawn from the training specifications and the behavioral data base, supporting the set of specific functional objectives. A training program was not developed during this phase, but substantial preliminary general groundwork was accomplished. Phase 2 will more directly address training program development in relation to a particular application in an experimental context.

D.2 METHODOLOGY

The development of the training program in Phase 1 involved review of existing training programs, development of a training program structure, construction of detailed guidelines, and creation of a diagnostic analysis scenario. These subtasks were performed serially to yield the elements that will comprise the training program.

a. Review of Existing Training Programs. The specifications of several maritime simulators were reviewed to determine if a maritime training program were incorporated as part of their system. Additional information was then requested from some of the facilities depending on the completeness of the program descriptions. A review of various types of existing programs aids the development of a training program by providing descriptions of possible alternative structures.

b. Development of Training Program Structure. A training program structure was constructed that addressed the courses, methods, and techniques of training. This structuring was based on an analysis of various simulator training program structures, a review of the wide range of skills addressed by the SFOs to be trained, and the need for an efficient, cost effective system.

c. Construction of Detailed Guidelines. Training analysts and marine consultants constructed a set of guidelines from which a training program could be developed. These guidelines detail the concepts to be covered for each area amenable to the use of simulator training. They will be used in Phase 2 when training program development regarding a particular application in an experimental context will be more directly addressed.

d. Creation of Diagnostic Analysis Scenario. A diagnostic analysis scenario that directs training emphasis by assessing trainee's strengths and weaknesses was created in response to the need for tailoring the training program structure.

D.3 RESULTS AND ANALYSIS

D.3.1 Simulator Training Program Review

Descriptions of training program structures for six training facilities were reviewed, but the data provided was sparse, since each facility considers its training program proprietary. The information drawn from the data supplied gave a broad overview of the classroom exercises, simulator exercises, feedback techniques, and training techniques of the six facilities (see Exhibit D-1). The areas addressed on the simulator by each of the six facilities are:

Institute TNO for Mechanical Constructions - steering tests, man overboard maneuvers, leading line sailings, anchorage approaches, harbor approach and enterings, and single buoy mooring maneuvers.

Computer Aided Operations Research Facility - exposure to new ports with their existing environmental conditions, emergency conditions, navigational constrictions or hazards, bridge management team, interaction of ship dynamics and channel, fog/heavy traffic/night operations, and the approach to unique facilities.

Marine Safety International - bridge crew training in shiphandling, and handling of problems such as equipment failures, human failures and sudden environmental changes.

Port Revel - fundamental shiphandling maneuvers in scaled ships with a 1/25 scale representation.

Southampton School of Navigation (Decca) - failure procedures, stopping distance, turning circle, zig-zag maneuver, Williamson turn, and the effect of wind and current.

Bremen Nautical Academy - execution of the exercise course prepared in the classroom by the trainees prior to entering the wheelhouse.

A comparison of these simulator programs indicated that fundamental shiphandling and casualty control are the major factors emphasized. However, two different training approaches are used: (a) team and procedural training as used, for example, by Southhampton School of Navigation and (b) practical shiphandling as used by Port Revel. The information derived from this analysis provided an overview of the possible alternative training structures that could be designed.

D.3.2 Training Program Structure

A highly flexible program structure is needed to respond to individual needs, train a wide range of skills, and still be efficient and cost effecitve. These requirements are achieved with a modular structure. Its advantages are many. Each module constitutes a cohesive training unit, which may either be independent or be grouped with others into courses.

The modular structure allows for the assessment of individual strengths and weaknesses so that the training program for each individual or set of individuals can vary based on input characteristics.

The SFOs were easily adaptable to the modular structure. They were divided into groups based on similar training needs. This process yielded a set of twelve modules:

a. Rules of the Road
b. Natural forces affecting shiphandling
c. Man-made variations to the environment
d. Vessel's mechanical parameters as related to shiphandling
e. Maneuvering
f. Tug assistance
g. Mooring and berthing
h. Equipments
i. Casualties
j. Local harbor conditions
k. Navigation
l. Integrated shiphandling

Topics covered within each module are listed in TABLE D-1. This resultant set of modules spans the breadth of the training program.

D.3.3 Detailed Guidelines

Detailed guidelines were developed for each module. These guidelines provide the framework within which the simulator training can and should be accomplished. The guidelines for each module provide an introductory page stating the objectives, materials needed, preparation, and required experience level. The content of the guidelines follows in tabular form. They address:

a. Topic
b. Action performed by monitor and/or trainee
c. Classroom objectives in the form of exercises or discussion
d. Simulator objectives for demonstration or hands-on training
e. Alternative training methodologies, and performance measures and standards (see Exhibit D-2).

During Phase 2, the guidelines will be further developed. Research issues not addressed in Phase 1 include the mix of classroom and simulator time, the relative effectiveness of demonstration on the simulator versus hands-on simulator use, and part-task versus whole-task training. These and other issues are itemized in section D.5.

Many training programs could be created from the guidelines that were developed to achieve the set of SFOs developed during Phase 1. It is, therefore, imperative that each

TABLE D-1. TOPICS COVERED WITHIN TRAINING MODULES

Module 1: Rules of the Road

A. General update
B. Boundary lines
C. Communications
D. Traffic separation schemes
E. Overtaking
F. Ambiguous situation
G. Meeting situation
H. CAS/radar

Module 2: Natural Forces Affecting Shiphandling

A. Tides
B. Current
C. Wind
D. Sea and swell
E. Visibility

Module 3: Man-made Variations to the Environment

A. Channels
B. Breakwaters
C. Bridges
D. Locks
E. Docks/berths
F. Background lights
G. Levees/dikes

Module 4: Vessel's Mechanical Parameters as Related to Shiphandling

A. Vessel configuration
B. Vessel speed
C. Propellers
D. Propulsion
E. Rudders
F. Bow thruster

Module 5: Maneuvering

A. Turning circle
B. Using application of rudder and propeller
D. Turns
E. Iniital maneuvering capability (zig-zag, spiral)
F. Emergency maneuvers
G. Stopping a VLCC
H. Helicopter transfer
I. Propulsion and control

Module 6: Tug Assistance

A. Utilizing tug assistance
B. Rules of the Road, towing
C. Components
D. Number of tugs
E. Placement of tugs

Module 7: Mooring and Berthing

A. Winches, capstans, ropes
B. Anchoring
C. Bow thrusters
D. Forces affecting mooring and berthing

Module 8: Equipments

A. Electronic navigation
B. Communications systems
C. Compasses
D. RDF
E. Controls
F. Indicators and dials

Module 9: Casualties

A. Anchoring and grounding
B. Minimizing an impending collision
C. Communications
D. Fire on board
E. Man overboard
F. Environmental pollution
G. Inoperative navigational aids
H. Rudder failure
I. Propulsion failure
J. Electrical failure
K. Communication failure

Module 10: Local Harbor Conditions

Module 11: Navigation

A. Plotting, turns
B. Current predictions
C. Man-made variations to the environment (effects)
D. Anchorages
E. Day/night navigation
F. Navigating to pilot station
G. Use of compass
H. Radar plotting
I. Conning to berth
J. Navigation using substitute aids
K. Avoidance

Module 12: Integrated Shiphandling

objective be included in one of the twelve modules. TABLE D-2 indicates that every SFO was incorporated into a module.

The SFOs are grouped into five broad areas of training as indicated below. The modules in which the SFOs are addressed are also listed.

- I. Fundamental Shiphandling
  - 1. Rules of the Road
  - 2. Natural forces affecting shiphandling
  - 4. Vessel's mechanical parameters as related to shiphandling
  - 5. Maneuvering
  - 11. Navigation
- II. Integrated Shiphandling
  - 1. Rules of the Road
  - 3. Man-made variations to the environment
  - 5. Maneuvering
  - 6. Tug assistance
  - 7. Mooring and berthing
  - 8. Equipments
  - 11. Navigation
- III. Emergencies
  - 6. Tug assistance
  - 9. Casualties
- IV. Team Coordination/Communication
  - 11. Navigation
- V. Bridge Procedure
  - 11. Navigation

It is interesting to note that the training program curricula reviewed addresses four basic areas of simulator training: (a) fundamental shiphandling, (b) integrated ship maneuvers; (c) bridge team training; and (d) emergencies. These four areas of training correspond almost exactly to the five areas addressed in the SFOs, indicating that the proposed curriculum is comprehensive.

To further ensure the completeness of the data included in the guidelines, the topics included in the "Study Guide to the Multiple-Choice Examinations for Chief Mate and Master" which addresses the areas of radar plotting/theory, deck-general, navigation, Rules of the Road and safety, were checked for their inclusion in the modules. The analysis indicated that all the topics included in the study guide were also included in the modules.

As a final check for guideline completeness, the content of the modules was compared with the data provided in Annex III, STW X/7, pages 11-14 of the IMCO Safety Committee

TABLE D-2. MODULES INCORPORATING SPECIFIC FUNCTIONAL OBJECTIVES

SFO NUMBER	MODULE NUMBER
IA 1-5	2
IB 1	5
IB 2-4	4
IB 5	5
IC 1-2	11
ID 1-5	5
IE 1-3	1
IIA 1	11
IIA 2-12	8
IIA 13	11
IIA 14	1
IIB 1	5
IIB 2-3	3
IIB 4-5	5
IIB 6-15	11
IIB 16-19	6
IIC 1-2	7
IID 1-2	7
IIE 1-3	7
III 1-5	9
III 6	6
III 7, 8, 9, 11	9
III 10	6
IV 1-2	11
V 1-2	11

document which specifies the "Minimum Knowledge Required for Certification as Master and Chief Mate". The comparison indicated that the modules addressed all the knowledge items required of a master and chief mate as specified by IMCO.

Based on the positive outcome of these three reviews (SFO, the study guide, and IMCO requirements) as to the inclusion of their content in the modules, it can be assumed that the detailed guidelines represent a comprehensive unit.

Note that the developed guidelines only provide the specifications from which many training programs could be developed. A final curriculum must address issues such as content, number, order, and timing of modules. Once these training programs are established, the critical issue will be to determine the effectiveness of each program. To accomplish this, the validity of each program (i.e., does the training program actually develop the skills and behavior for which it was designed?) must be determined empirically. However, there are several stages of validity which must be seriously appraised (Goldstein, 1978).

a. The first stage is that of establishing "training validity". Training validity as defined herein does not imply that the behavior effected is transferable to the real world or actual job situation. In this context, it refers merely to the fact that as a result of the individual's involvement in the training program, a change in performance has been established. This change in performance, however, is only realized with respect to the training program showing a difference in performance on the training tasks between pretraining measures and posttraining measures. The question of transfer to on-the-job performance is not addressed.

   Some important factors relative to training validity are: (a) need assessment, (b) evaluation and (c) understanding.

   Need assessment refers to the goals and objectives of the training program (i.e., the training program must meet the characteristics of the trainee populations). Through a task analysis (see Appendix A) the goals and trainee characteristics of a specific job for which individuals are to be trained can be identified.

   Evaluation refers to the appropriateness of the training program design. Such issues as the control of irrelevant variables, the standardization of the program and the specific "independent" variables which are thought to have an influence upon the skills and abilities to be trained must be established.

   Understanding also refers to the effects of the training program to be used. However, understanding differs from evaluation in that the rationale for using specific training conditions and controls must be specified such that the validity of the program makes sense with respect to the behaviors being trained.

b. The second stage of validity is that of "performance validity". Performance validity goes a step further than training validity in that it refers to the positive transfer of training from the program to on-the-job performance. With respect to this form of validity, the need assessment must be concerned with meeting on-the-job goals. Job components must then be assessed with respect to their importance, frequency of occurrence and the difficulty with which they can be learned. To meet the need requirements of on-the-job

performance, the resources of a particular company and its organizational constraints must be clearly defined. Conflicts between unions, government, and operators must be considered along with the cost benefits from such training. The technological constraints in terms of the sophistication of equipment available to train specific skills and abilities must be assessed in order that these skills and abilities may be transferred to the real world. For example, the sophistication of available simulation technology appropriate for the training of certain shiphandling tasks such as docking and maneuvering in shallow water would have to be evaluated. Furthermore, the devices which individuals would be trained to use must be relevant to equipment in use on present day ships. Training to use devices which may not be put into general usage until a decade from today's state-of-the-art equipment would not be considered.

Evaluation and understanding also apply to performance validity but are of necessity more comprehensive and extensive in their scope than was the case for training validity. Evaluation would have to include measurement of performance in both the training situation and on the job. A more comprehensive understanding of the union, government, and operator's goals must also be specified such that the structure of the training program serves to meet these goals.

c. The third stage of validity is that of "intra-organizational validity". Intra-organizational validity is most concerned with changes that take place in terms of the frequency of task occurrence and changes which take place in the organizational goals. Under such conditions the training program must allow for specific revisions to meet the demands of changing organizational goals and job components. New information about revisions in job definition must therefore be supplied to modify the need requirements of a pre-existing training program. If such actions are not taken, new groups engaged in training may find that the program is no longer applicable to existing conditions (Goldstein, 1974).

d. The fourth stage of validity is that of "inter-organizational validity". For this form of validity, the training analyst is concerned with the generalizability of a training program developed for one organization relative to its application in training personnel from a different organization. If the job components and level of proficiency required of individuals differ among organizations, generalizing the training program can be quite dangerous aside from being ineffective. Evaluation and understanding for the case of inter-organizational validity would require the most intense assessment of the similarities and differences of the various organizations before any consideration of generalizability can be made. Most important, however, would be the evaluation requirement. Since precise control may be impractical due to differences among organizations, evaluation of the training program may be prohibited. For example, some types of vessels as well as some shipping companies require different bridge procedures which vary with respect to the number of men on the bridge watch, and the job definition of bridge officers. Under such conditions generalizability of a shiphandling training program must set up minimum standards. The operators may then deviate from these standard procedures as they wish but at the same time maintain a common set of operations which would allow for the assimilation of different individuals into the bridge watch procedure with little conflict and less training.

The four stages of validity (i.e., training, performance, intra-organizational, and inter-organizational validity) must be appraised in determining the overall validity of any training program.

D.3.4 Diagnostic Analysis Scenario

A diagnostic analysis scenario which would aid in directing the training emphasis was formulated. The scenario is a comprehensive set of representative situations drawn from each of the twelve modules. It will assess areas of strength and weakness by identifying the level of skill possessed by each trainee for each module.

Several constraints were imposed prior to the development of the scenario. Such constraints were that: (a) the scenario could run for no longer than one hour, so as to make the most efficient use of the device, (b) it must address skills which span all twelve modules, and (c) it would be used prior to the trainee undergoing training.

The resultant scenario was divided into definitive independent segments, each complete within itself. For example, the first segment may start at the sea buoy and proceed to picking up a pilot, while the second segment may deal with maneuvering around the first bend of the channel. The total scenario length is 40 minutes. Exhibit D-3 contains this scenario in tabular form in its entirety. It is of importance to realize that at present, this is only an illustration of a possible diagnostic scenario which will be modified based on the various training programs developed. Scenario design must address such issues as levels of fidelity and complexity, the amount of secondary information provided, and the quality, quantity, and timing of information provided. Further developmental efforts must then address such issues as sequencing of events, amount of detail, and validity. Other design and developmental issues are listed in section D.5

D.4 CONCLUSIONS AND RECOMMENDATIONS

From the training program development to date, the following conclusions and recommendations have arisen.

a. Deck officers likely to enter simulator-based shiphandling training programs are expected to possess widely varying levels of skill proficiency. The training programs should be responsive to these individual differences to make effective use of the deck officer/trainee's time, and thus achieve an efficient and effective training process.

b. A modular training program structure was developed as responsive to the particular needs of deck officer training. This structure would provide the flexibility needed to allow for the assessment of individual strengths and weaknesses so that the training program could meet the needs of each individual or set of individuals, based on the particular set of skills and knowledge present.

c. A set of twelve modules was designated as comprising the training program structure:

   1. Rules of the Road
   2. Natural forces affecting shiphandling
   3. Man-made variations to the environment

4. Vessel's mechanical parameters as related to shiphandling
5. Maneuvering
6. Tug assistance
7. Mooring and berthing
8. Equipments
9. Casualties
10. Local harbor conditions
11. Navigation
12. Integrated shiphandling

d. The detailed training program guidelines provide the framework from which one or more training programs could be developed.

e. The diagnostic analysis scenario, which was developed as an example, demonstrates the potential and the use of a method of assessing the deck officer/trainee's strengths and weaknesses. The results of its application would be instrumental to the subsequent tailoring of the modular training program.

f. Appropriate contexts for the accomplishment of deck officer shiphandling training may be a combination of:

1. Classroom instruction and feedback
2. Demonstration on a simulator
3. Hands-on control of the vessel on a simulator

D.5 RESEARCH ISSUES

A list of research issues related to training program development follows:

a. The empirical evaluation of the characteristics of simulator-based training programs developed from the guidelines:

1. Mix of classroom and simulator time
2. Relative effectiveness of demonstration on the simulator versus hands-on simulator use
3. Group size for simulator-based training
4. Time compression (e.g., simulator time running five times real time)
5. Feedback information pertaining to each module, including timing (i.e., immediate versus delayed), content, and mode of representation
6. Instructor's role
7. Part-task versus whole-task training
8. Individual versus team training
9. Massed versus distributed practice

b. Validation of the recommended training program structure, including the modular concept and use of the diagnostic analysis scenario:

   1. Content of modules
   2. Number of modules
   3. Order of modular presentation, interactions between modules
   4. Time per module

c. Development of modules for refresher and other types of training

d. Transfer of training to the real world as a function of the training program characteristics

e. Training decay/retention as a function of the training program characteristics

f. Scenario design issues:

   1. Scenario length
   2. Level of fidelity
   3. Level of complexity (e.g., number of extraneous targets)
   4. Interactive target bridges versus "canned" target
   5. Specific harbor versus hypothetical harbor
   6. Performance measures and standards
   7. Amount of secondary information (e.g., radio information, visual scene)
   8. Existence of an escape route to avoid problems (i.e., available or not)
   9. Sequencing of scenarios on the basis of operational considerations (e.g., four 1-hour segments making up a 4-hour watch)
   10. Effectiveness of short scenarios for certain SFOs (e.g., scenario beginning immediately preceding emergency, as opposed to surprising trainee with the emergency); effectiveness of three 20-minute scenarios as opposed to one 1-hour scenario.
   11. Amount of extraneous information (e.g., radio clutter)
   12. Masking of the situation versus obvious situation
   13. Time of day
   14. Quality, quantity and timing of information presented to trainees
   15. Number of relevant events per scenario and their sequencing

g. Investigation of the development and use of the diagnostic analysis scenario:

   1. Amount of detail - aimed at modular level or more finite level within individual modules
   2. Sequencing of events within the scenario and their timing
   3. Effectiveness of diagnostic evaluation in terms of its ability to discriminate between levels of proficiency
   4. Validity

5. Reliability
6. Amount of time necessary as a function of areas evaluated
7. Appropriate scenario situations
8. General situations versus specific ship and port situations

h. Development and evaluation of a prototype training course based on the guidelines.

EXHIBIT D-1

SIMULATOR TRAINING PROGRAMS

TRAINING PROGRAMS	CLASSROOM	SIMULATOR	FEEDBACK	TRAINING TECHNIQUE
Institute TNO for Mechanical Constructions	1. Lectures on ship maneuvering 2. Information on the maneuvering characteristics of the ship used during simulation	1. Steering tests (¼ to ½ hr) 2. Man overboard Maneuver (½ to 1½ hr) 3. Lead Line Sailings (½ to 1½ hr) 4. Anchorage Approaches (½ to 1½ hr) 5. Harbor Approach and Enterings (20 min. to 1 hr) 6. Single Buoy Mooring Maneuvers (45 minutes)	Discussions on executed navigational task or maneuvering problem	1. Classroom lecture 2. Simulator — a. Hands-on b. Post problem critique

TRAINING PROGRAMS	CLASSROOM	SIMULATOR	FEEDBACK	TRAINING TECHNIQUE
Computer Aided Operations Research Facility	Discussions/lectures to meet unique objectives	1. Exposure to new port prior to actual ship navigation to give the crew experience and to develop tentative port operating procedures. 2. Experience given in a full range of port environmental condition. 3. Encounters with emergency conditions coupled with routine and more critical navigational constrictions or hazards. 4. Development of a bridge management team as an effective unit. 5. Interaction of ship, dynamics and channel. 6. Fog/heavy traffic/night time port operations. 7. Approach to unique facilities (offshore terminals).	1. Observations can be videotaped in total or in specific detail. 2. Location and actions of the individual officer or crew can be recorded and radar plotting skills monitored visually or on videotape. 3. Visual observations supplemented by computer-calculated measurements. At the end of each operational run, these data can be analyzed to determine average performance or other statistical trends. 4. CAORF simulator plots own ship and other ship's track data on graphs.	Post problem critique

TRAINING PROGRAMS	CLASSROOM	SIMULATOR	FEEDBACK	TRAINING TECHNIQUE
Marine Safety International		1. Hands-On bridge crew training in ship handling. 2. The system provides for injecting the unexpected problems such as equipment, human failures, and sudden environmental changes.	1. Training exercises can be stopped and/or completely replayed for evaluation and discussion. 2. Freeze Record Playback	Simulator — a. Hands-on b. Critique/ discussion of exercises.

TRAINING PROGRAMS	CLASSROOM	SIMULATOR	FEEDBACK	TRAINING TECHNIQUE
Port Revel	1. Instructor presentations used for introduction of data presenting principles and setting the stage for group discussion. 2. Series of units — each covering an important aspect of ship handling.	1. Practice of the fundamentals of ship handling maneuvers in scaled ships on the lake. 2. 1/25 scale representations.	1. Critique of lake maneuvers.	1. Classroom — a. Lecture/discussion b. Use of charts, recordings, slides, and audio-visual materials. 2. Simulator — Post problem critique.

TRAINING PROGRAMS	CLASSROOM	SIMULATOR	FEEDBACK	TRAINING TECHNIQUE
Southampton School of Navigation (Decca)	1. All simulator exercises will be preceded by instructor discusssion. 2. Course is divided into 10 exercises.	1. Maneuver the vessel in various exercise situations: a. Failure procedures b. Stopping distance c. Turning circle d. Zig-zag maneuver e. Williamson turn f. Effect of current and wind.	1. Analysis of the completed exercise and subsequent discussions	1. Classroom – Lecture 2. Simulator– Post problem critique/ instructor and student discussions.

TRAINING PROGRAMS	CLASSROOM	SIMULATOR	FEEDBACK	TRAINING TECHNIQUE
Bremen Nautical Academy	1. Group has to prepare the course for the exercise before entering the wheelhouse. 2. Group determines which data or observations are to be taken note of so that the acquired knowledge and experience can be retained and applied by later exercises.	1. Upon entering the wheelhouse the ship is "frozen" in position for departure appropriate to the exercise.	1. During simulator exercises, the instructor supervises and makes recordings for later discussion.	1. Classroom — Problem solving discussion. 2. Simulator — Post problem critique.

EXHIBIT D-2

CURRICULUM GUIDELINES

CURRICULUM GUIDELINES

MODULE - RULES OF THE ROAD

Objectives:

1. Give the trainee confidence while applying Rules of the Road in maneuvering a VLCC in confined waters with varied traffic situations and visibility.
2. Improve the trainee's skill and accuracy of radar plotting and assessment of targets.
3. Familiarize the trainee with communication procedures
   a) to other vessels maneuvering
   b) to shoreside control stations.

Materials Required:

1. Copy of USCG #169 of 5/1/77 - Navigational Rules - International/Inland
2. Texts and maritime publications such as:
   a) Farwell's Rules of the Nautical Road - Fifth Edition
   b) Knight's Modern Seamanship - 16th Edition - Part IV
3. Marine Radio Telephone Book
4. Radar PPI scope - Manuevering Board Equipment
5. Radio telephone circuits and feedback

Preparation:

Review of Rules of the Road in texts - Review of FCC and USCG Marine Telephone Regulations

Experience Level:

The trainee should have a high experience level with use of the Rules of the Road for this module, due to day-to-day application. A brief review may be sufficient to assist the trainee in becoming proficient in maneuvering a VLCC under varied conditions of traffic and visibility.

MODULE - RULES OF THE ROAD

TOPIC: GENERAL - UPDATE

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	1A Review international Rules of the Road - Emphasize the updating of the 1972 rules from the 1960 rules such as: a) Modifications to wording b) New rules c) New definitions d) Metric dimensions e) Traffic separation schemes f) Technical details g) Performance standards h) Sound signals. 1B Review inland Rules of the Road including sound signals.	1. Show various combinations of situations/lights of vessels in close proximity during: a) Daylight b) Night time Have trainee orally describe various lights and situations presented and have him give the proper interpretation.	C) Seminar Type Discussion S) Oral Proficiency Evaluation based on response to visual displays	Trainee to have understanding of the 1972 International Rules of the Road by achieving a 90% passing grade.

TOPIC: BOUNDARY LINES

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	2. a) Discuss boundary lines of inland waters b) Evaluate the changes necessary in navigating between international and inland waters c) Develop basis of firmly determining which jurisdiction applies.	Take fixes and plot on chart to ascertain vessel's position - inland or international waters.	C) Using charts, sailing directions, coast pilot, or CG 169, identify boundary lines C) Use of legal definitions from court decisions C) Seminar Discussion S) Post Problem Critique	

TOPIC: COMMUNICATIONS

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	3. a) Discuss the requirements and use of the radio-telephone as an aid in safe navigation of vessels and assisting in predicting maneuver b) Discuss details such as: 1. Terminology 2. Phrasing - sample messages 3. Format 4. Recording 5. Appraising traffic situations 6. FCC and USCG regulations.	1. On scenario runs, guard radio-telephone traffic, reply/initiate calls as necessary. Involve trainee with: a) Routine intentions of vessels readily understood and able to carry out. b) Difficult - initial information or intentions of other vessel confusing to trainee c) Garbled messages - run continues with a risk of collision possible d) Emergency or casualty traffic.	C) Seminar Type Discussion S) Post Problem Critique	Ensure trainee has a clear concept of bridge-to-bridge communications including navigating/communicating under adverse conditions

TOPIC: COMMUNICATIONS

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	4. Discuss communication requirements related to traffic advisory areas such as: a) Vessel movement b) Reporting authorities c) Required reports d) Timing of reports.	Trainee to reply/initiate calls to individual authorities as scenario develops.	C) Seminar Type Discussions S) Post Problem Critique of trainee response to actual conversations	Trainee's ability to clearly communicate.
M & T	5. Show differences and requirements of traffic communications at harbor installations where advisories are in use. Show the routines versus special requirements in certain harbors such as: a) Mississippi River b) San Francisco c) Puget Sound d) Prince William Sound e) New York f) etc	Trainee to reply/initiate calls to individual authorities as scenario develops.	C) Study and discussion of harbor regulations	

TOPIC: TRAFFIC SEPARATION SCHEMES

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	6. I) Acquaint trainee with IMCO adopted trafric schemes where promulgated II) Discuss schemes of ships routing: a) Terminology b) Symbols c) Meaning of various presentations on charts d) Description of details e) Methods of implantation - joining/ leaving separation lanes	Maneuver VLCC in: a) various traffic separation schemes b) through "Roundabout" c) each of the above - own ship and combinations of traffic: 1. Routine 2. Other vessel not following correct procedures.	C) Use charts/ diagrams to illustrate the harbor approach schemes. S) Post Problem Critique for each section of simulator activity	Trainee has thorough background in traffic schemes and maneuvers - vessel properly in zones of traffic.

TOPIC: OVERTAKING

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	7. Discuss what communications to use and the action to take in an overtaking situation, when own ship is astern and wants to pass the other vessel on starboard side. Own ship is: a) Stand-on b) Give-way. Maneuver executed in: a) Restricted waters b) Open sea. 8. Discuss the "International Regulations for Preventing Collisions at Sea" and "Basic Principles to be Observed in Keeping a Navigational Watch".	Complying with the Rules of the Road, conn own ship safely to complete an overtaking maneuver: a) In restricted waters b) Open sea. When own ship is astern and wants to pass the other vessel on the starboard side and own ship is: a) Stand-on b) Give-way.	C) Slides C) Audio Visual Aids C) Problem Solving S) Post Problem Critique for each section.	Overtake in open sea - CPA of 1 mile. Overtake in restricted waters minimum of 200' (channel width of 700').

TOPIC: AMBIGUOUS SITUATION

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	9. Discuss what communications to use and what action to take in an ambiguous situation (i.e., can't tell if a crossing or meeting situation exists). Own Ship is: a) Stand-on b) Give-way	Complying with the Rules of the Road, conn the VLCC safely when an ambiguous situation exists in Open Sea. Own ship is: a) Stand-on b) Give-way	C) Slides C) Audio Visual Aids C) Problem Solving S) Post Problem Critique for each section	Avoid a collision in Open Sea - CPA of 1 mile minimum

TOPIC: MEETING SITUATION

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	10. Discuss what action to take and what communication to use when maneuvering in a head to head meeting situation.	Complying with the Rules of the Road, conn the VLCC safely up the channel in a head to head meeting situation.	C) Slides C) Audio Visual Aids C) Problem solving S) Post Problem Critique for each section	CPA in restricted waters nm

TOPIC: CROSSING SITUATION

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	11. Discuss what action to take and what communications to use when maneuvering in a crossing situation. Own ship is: a) Stand-on b) Give-way.	Complying with the Rules of the Road, conn the VLCC safely when a crossing situation exists in open sea and own ship is: a) Stand-on b) Give-way.	C) Slides C) Audio Visual Aids C) Problem solving S) Post Problem Critique for each section	CPA minimum of nm in open sea.

TOPIC: CAS/RADAR

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	12. Discussion of the following as they pertain to CAS/radar use in Rules of the Road and Collision Avoidance: a) Capabilities and Limitations of various CAS/Radar b) Choice and use of controls such as range scales, intensity and gain values on different radars c) Evaluation of contacts (i.e., range bearing, CPA, area of danger and time to CPA). d) Predict possible evasion course of threats e) Choice of display modes f) Auxiliary equipment required for CAS inputs. g) Detection of sea return, false echoes, and malfunctions.	While conning in the open sea with approximately 20 contacts, sea state 4 and reduced visibility - 1. Use the CAS/radar to show contacts that they are a possible threat to own ship 2. From contacts that are threats, make avoidance decision taking into account: a) CPA b) Initial range and bearing of targets c) Range, bearing, and time to CPA d) Course change to avoid collision-trial/actual e) CPA of altered course f) Time to return to base course 3. Conn vessel in harbor conditions and perform #2 with channel restraints.	C) Problem solving discussion S) Post Problem Critique	1. Examine up to 20 contacts simultaneously and evaluate each target for a threat 2. Within 2 minutes show a threat's time/bearing range to CPA 3. Execute trial maneuver within 6 minutes of initial contact.

CURRICULUM GUIDELINES

MODULE - NATURAL FORCES AFFECTING SHIP HANDLING

Objectives:

This module will enable the trainee to understand the natural forces he must contend with, in varying degrees, while handling a vessel. A review of the cause and effect of these forces will be presented. Discussions of specific examples of forces in harbors and waterways will form the basis of instruction. Meteorological data will also be introduced to show how each specific item may affect ship handling.

Preparation:

Review - Reading texts such as:

Bowditch (1977 Edition)
Part 5 & 6 - Oceanography and weather

Dutton - 13th Edition - Chapter 9, 10, 12 - Currents and Tides

Merchant Marine Officers Handbook - Chapters 4 and 7

Knight's Modern Seamanship - 16th Edition - Part III - Oceanography and Weather

Material Required:

Show examples of:

A. Charts of major harbors, large rivers, islands, coast lines, ship canals, estuaries (to have a broad view of the varying types of conditions and to be aware of the location of existing natural forces)

B. Chart of Port XYZ having a composite of the variation noted in the above selection of charts

C. Tide Tables

D. Current tables, diagrams, and charts

E. Light List - Issued by USCG

TOPIC: TIDES

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	1A Discussion on a broad basis of the causes of tides to show: 1. Their natural cycles and occurrence 2. Reasons for variations in range 3. Their datums 4. Relationship of tide to meteorological effects (i.e., wind barometric pressure). 1B List the appropriate navigational publications on tides and currents and explain how to calculate tidal conditions.	Conn the VLCC through the channel under the following tide conditions: 1. Height a. 0-5 FT b. 5-10 FT c. 10-15 FT 2. Ebb (Ahead) 3. Flood (Astern)	C) Seminar Type Discussion Trainee to be given: 1. Problems of determining the height of the tide at any time or place from tide tables 2. Problems on optimum time of ETA at varied parts of harbors because of water depths S) Post-Problem Critique (feed-back) for each section 1-2-3 of Simulator activity.	S) Maintaining intended track within $\pm 2^0$ C) 1. Accuracy of predictions a. time b. height C) 2. Amount of time to arrive at correct answer

MODULE - NATURAL FORCES AFFECTING SHIP HANDLING

TOPIC: CURRENT

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	2. Discussion of the causes of currents and oceanic circulations. 3. Discussion describing specific currents of the world. 4. Discussion of tidal currents such as: a. Relation between time of [illegible]/current b. Relation between speed and range of tide. 5A Show how topographical features affect currents: a. shoreline b. man-made barriers c. depths d. channel/river differences between concave/convex shores e. eddy currents. 5B Discuss the appropriate navigational publications on tides and currents that are used to determine tidal conditions.	1. Using the combination of ahead, astern and abeam of: Conn the VLCC through the channel under the following current conditions: a. 0-1 KT b. 2-3 KTS c. 4-5 KTS 2. Conn the VLCC through a river channel with bends and eddy currents. 3. Conn the VLCC through a channel with varying depths and currents.	C) Seminar Type Discussion S) Post-Problem Critique (feedback) Note effects on vessel as it proceeds through channel.	S) Maintaining an intended track within $\pm 2^{o}$

TOPIC: DISCUSSION OF WIND

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
Predominately by Monitor. Trainee will contribute his experiences and observations to the discussion.	6. a. Discussions describing global wind; the causes and effects and how they influence currents, the cause/effect of heat creating sustained or prevailing winds b. Review general circulation of atmosphere and modifications. 7. Discuss seasonal, localized, and diurnal winds in different parts of the world and how they modify harbor navigation. 8. Review problems of catastrophic winds, their predictability and evasion tactics.	Conn the VLCC at 14 KTS through the channel under the following wind conditions: 1. Wind Position a. Beam wind b. Astern wind c. 45^0 each bow d. 45^0 each quarter 2. Wind Speed (KTS) a. 0-10 KTS b. 10-20 KTS c. 30-40 KTS d. over 40 KTS.	C) Seminar Type Discussion S) Post Problem Critique for each section (i.e., 1a, 2b) of simulated activity.	S) Deviation from intended track $\pm 2^0$

TOPIC: DISCUSSIONS OF WEATHER

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	9. Discuss weather predictions and how they are obtained (e.g., wind directions in immediate future). 10A Show how forecasts can be useful in harbor transits. 10B Review weather predictions - UHF, teleprinter output, weather maps. 10C Discuss the characteristics of various weather systems, including tropical revolving storms, avoidance of storm centers, and dangerous quadrants. 10D Discuss how to handle own ship under heavy weather conditions including assisting a ship in distress, towing operations, and the means of keeping an unmanageable ship out of the sea trough and lessening drift, use of oil, etc.	9A Forecast area weather. 9B Maneuver the vessel in the open sea under the following weather conditions: a) Rain squalls b) Hurricane coming from the west, own ship heading north. 10 Maneuver the vessel under heavy weather conditions to assist a ship in distress using towing operations to keep an unmanageable ship out of the sea trough and lessening drift.	(C & S) Seminar Type Discussion	(C & S) Evaluate trainees understanding of weather forecasting.

TOPIC: VISIBILITY

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	11. Discussion of fog: a. Causes b. Difference between radiation and advection fog c. General areas where fog is likely to be encountered. 12. Show the reduction in range for sighting navigational lights due to the change in transparency of the atmosphere. 13. Discuss re-orientation needed during times of reduced visibility due to fog or haze in scenarios which require guidance of the VLCC through harbor. 14. a) Using luminous range diagram in light list, work problems of different combinations of meteorological visibility.		C) Seminar Discussion C) Use of light list S) Post Problem Critique	

CURRICULUM GUIDELINES

MODULE - MAN-MADE VARIATIONS TO THE ENVIRONMENT

Objective:

In this module, the trainee will be presented with various examples of man-made variations to the environment. These examples will be as shown on the "Port XYZ" chart. The trainee will be acquainted with background to assist him in properly compensating for locally encountered conditions that often adversely affect ship handling, if not considered.

Preparation:

Study and discuss chart of "Port XYZ."

Experience:

Since this module combines characteristics of many ports, the pilot/master may be acquainted with these conditions from his previous experiences.

TOPIC: Local Harbor Conditions

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	1. Discussion of the following items which outline the examples of specific harbor conditions that will be considered: a) channels 1. flow-concave versus convex, counter currents 2. effects such as bank, suction, drag, squat b) breakwaters-showing cross currents c) bridges 1. abutments-eddy and flow around 2. constricted maneuvering d) locks-turbulence compensation required e) docks/berths-cushion effects f) background lights-difficulty of recognizing shore side navigational aids or vessel's running lights g) levees-dikes-localized current variations.	Conn the VLCC through Port XYZ compensating for the local variations noted in classroom discussion (a through g). Evaluate compensation required for course-correction in each example.	C) Seminar Type Discussion S) Post Problem Critique	

CURRICULUM GUIDELINES

MODULE - VESSEL'S MECHANICAL PARAMETERS AS RELATED TO SHIP HANDLING

Objective:

Upon completion of this model, the trainee will be able to identify variations of the following items of vessel parameters and compensate, minimize, or take advantage of their influence on ship handling:

a) vessel configuration
b) vessel hull form
c) bulbous bow
d) rudder
e) horsepower/speed
f) propellers
g) propulsion - types
h) bow thruster.

Preparation:

Review the following texts:

Modern Ship Design - Chapters 3, 9, 10, 11

Experience Level:

The trainee's level of experience will be low for immediate application to a 170,000 DWT vessel since he has previously handled vessels of much less tonnage.

TOPIC: Vessel Configuration

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	1A Discuss how the VLCC configuration (i.e., high block, low power) and the hull form (i.e., bulbous bow) of a 170,000 DWT tanker influences shiphandling. B Discuss how loading conditions and draft affect a VLCC with the above configuration. Use stability, trim and stress tables, diagrams, and stress calculating equipment to determine proper loading. C Discuss IMCO regulations concerning ship stability.	1. Conn a VLCC (with a high block, low power configuration and a bulbous bow hull form) through the channel under the following conditions: a) ballast b) fully loaded c) varying draft	C) Seminar Type Discussion S) Post Problem Critique for each condition	

MODULE — VESSEL'S MECHANICAL PARAMETERS AS RELATED TO SHIP HANDLING

TOPIC: Vessel Speed

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	2. a) Discuss how the speed range of a VLCC influences ship handling maneuverability b) Discuss the amount of time it would take for a speed change to be accomplished if going from: a) 16 KTS to 10 KTS b) 10 KTS to 6 KTS c) 6 KTS to 1 KT d) 10 KTS to 16 KTS c) Discuss how the ship's speed capability will influence the judgement of avoidance maneuvers, docking, entering harbor, entering open sea.	2. a) Conn the VLCC from open sea into harbor reducing speed to 10 KTS. b) Conn the VLCC through the channel to the dock reducing speed accordingly. c) Conn the VLCC from harbor into open sea increasing speed to 16 KTS. d) Determine the vessel's reaction and amount of time required to go from: a) 16 KTS to 10 KTS b) 10 KTS to 6 KTS c) 6 KTS to 1 KT d) 10 KTS to 16 KTS.	C) Seminar Type Discussion S) Post Problem Critique for each section of simulator activity.	

MODULE – VESSEL'S MECHANICAL PARAMETERS AS RELATED TO SHIP HANDLING

TOPIC: Propellers

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	3. Discuss how the amount of ship and thrust are influenced if a VLCC is equipped with the following type of propeller: a) controllable pitch b) single screw c) twin screw.	3. Conn a VLCC through a channel leg, compensating for propeller slippage if the VLCC is equipped with the following type of propeller: a) controllable pitch b) single screw c) twin screw.	C) Seminar Type Discussion S) Post Problem Critique of each section (i.e., 3A, 3B, 3C) of simulator activity	

TOPIC: Propulsion

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	4. Discuss the various means of propulsion available to a VLCC and discuss the capabilities and limitations of each such as: a) diesel powered b) steam 1. turbine 2. turbo-electric c) gas turbine.	4. Apply the following astern RPM and note the effectiveness: a) dead slow b) slow c) half d) full.	C) Seminar Type Discussion S) Problem Solving Exercises	

MODULE – VESSEL'S MECHANICAL PARAMETERS AS RELATED TO SHIP HANDLING

TOPIC: Rudders

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	5. a) Discuss how the effectiveness of rudder and the time required to apply the rudder effect on the steering characteristics. b) Discuss the influence of speed on the effectiveness of the rudder.	5. a) Apply the following rudder angles and note their effectiveness and response time when traveling at: 1. 16 KTS 2. 10 KTS 3. 6 KTS 4. 1 KT b) Rudder angles of: 1. 5° right; left 2. 10° left; right 3. 15° right; left 4. 20° left; right 5. rudder amidships 6. full right rudder 7. full left rudder	C) Seminar Type Discussion S) Demonstration	

MODULE – VESSEL'S MECHANICAL PARAMETERS AS RELATED TO SHIP HANDLING

TOPIC: Bow Thrusters

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	6. a) Discuss how bow thrusters influence the VLCC's ability to aid in overcoming the problem of directional control at low speed. b) Discuss various situations in which the bow thruster would be used. c) Discuss how bow thrusters can be used to aid the tugs while docking.	6. Maintain directional control of a VLCC by using a bow thruster in each of the following situations: a) maneuvering in close quarters in a harbor at low speed (2 KTS) b) underway with no way on c) assist in the docking operation.	C) Seminar Type Discussion S) Post Problem Critique for each section under simulator activity	

CURRICULUM GUIDELINES

MODULE - MANEUVERING

Objective:

To provide the trainee with an understanding of the dynamic characteristics of vessels such as geometry of the turning circle, vessel center of gravity, the interaction of the rudder with propeller, and speed will provide the trainee with valuable knowledge to apply to the vessel handling and specific information to use on individual vessels. Various types of turns as well as procedures to stop will also be considered in this module. This will assist him to predict what the response of the vessel will be as well as its reaction time when applying rudder and power. Also, a helicopter transfer will be discussed and simulated for indoctrination.

Preparation:

Reading of text such as:

1. Knight's Modern Seamanship - Chapters 1, 10, 12 - 16th Edition
2. Modern Ships - Gillmore - Chapter 10
3. Basic Ship Theory - Volume 2 - Chapter 13
4. Dutton's Navigation and Piloting - 13th Edition - Chapter 13.

Experience Level:

Large variations in specific levels of knowledge are expected to exist depending on the extent of the previous exposure to this material.

MODULE – MANEUVERING

TOPIC: Turning Circle

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	1. Discuss and illustrate the geometry of the turning circle. Include the following in the discussion: a) drift angle b) advance c) transfer d) tactical diameter e) diameter of steady turning circle f) pivoting point g) vessels center of gravity	1. Turn the VLCC in a complete circle to see its response under the following conditions: Rudder a) left full rudder b) right full rudder c) left 15° d) right 15° Own Ship Speed a) 14 KTS b) 10 KTS c) 6 KTS	C) Discussion S) Demonstration	C) Understand the theory of the turning circle S) Accurately record the turning characteristics of the ship under the listed conditions

MODULE – MANEUVERING

TOPIC: Forces Effecting Turns

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	2. Discuss why the force on a rudder causes the following: a) development of a turning moment b) development of a broadside movement away from the center of the turn c) development of a "drag" reducing the vessel's speed on turn d) how own ship's speed influences the effectiveness of the rudder.		1. Seminar with texts Type Discussion 2. Training Aids	

MODULE – MANEUVERING

TOPIC: Forces Effecting Turns

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	3. Discuss the angle of heel when turning. Include in the discussion: a) forces acting on the hull and rudder b) amount and direction of heel during steady turn c) direction of heel when rudder is initially put over d) what happens if during a steady turn: 1. the rudder angle is suddenly taken off? 2. the rudder angle is suddenly reversed?	3. Maneuver the vessel through a steady turn noting the effects: a) when the rudder is suddenly taken off b) when rudder angle is suddenly reversed	C) Seminar Type Discussion S) Post-Problem Critique for each individual section	

TOPIC: Using Application of Rudder and Propeller

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	4. Discuss how to effectively use both the propeller (kick effect) and the rudder to maneuver: a) around a sharp turn b) alongside a berth	4. Conn the VLCC through sharp bends and turns in a channel when turns are: a) greater than 90° b) 60° to 90° c) less than 60° In scenario of (a), (b), and (c) above use speeds of: a) 14 KTS b) 10 KTS c) 6 KTS Calculate the differences of ship response with changes of speed (above) with rudder.	C) Seminar Type Discussion S) Post-Problem Critique for each segment.	S) a. Maintain heading of ± 2° b. swept width (beam + 0.[illegible]L) c. judgement as to when to initiate the turn

TOPIC: Turns

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	5. Discuss turns: a) Difference between: 1. right/left 2. speed b) Response time-"lag" c) Attempts to judge "by eye"	Execute starboard and port turns projecting own ship's track under the following conditions: a) rudder angles no greater than 25° b) speeds up to 16 KTS in open sea c) speeds up to 10 KTS in restricted waters d) explain how port and starboard turns differ in initial effectiveness	C) Seminar Type Discussion S) Post Problem Critique for each	S) Accuracy of track projection

MODULE – MANEUVERING

TOPIC: Initial Maneuvering Capability

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	6. Discuss how the spiral maneuver provides an indication of a ship's directional stability or instability.	6A. In open waters, execute and plot a spiral maneuver, projecting own ship's track. Begin by putting over a 15° starboard rudder.	C) Visual Aids and Discussion S) Post Problem Critique (feedback)	S) Make proper turn sequence at at the appropriate time
		6B. Examine plot of spiral maneuver and evaluate ship's directional stability.		Accuracy of track projection
T & M	7. a) Discuss how a zig-zag maneuver is used to study initial response of a ship to rudder movements.		C) Seminar Type Discussion	
	b) Explain how to execute a zig-zag maneuver.	7A. In open waters, execute and plot a zig-zag maneuver, projecting own ship's track, using no greater than a 20° rudder angle.	C) Visual Aids S) Post Problem Critique(feedback)	C) Make the proper turn sequence at the appropriate time
		7B. Determine from plot of zig-zag maneuver the initial rudder response.		Accuracy of track projection

MODULE — MANEUVERING

TOPIC: Emergency Maneuvers

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	8. Discuss various emergency turns or maneuvers such as: a) Williamson turns b) single "round turn" c) two turn circle d) full backing	8A. Execute (a) to (d) of number 8 classroom exercises to pick up a man overboard or approach a small vessel in reduced visibility 8B. Compare the advantages or disadvantages of each emergency maneuver and determine the application of each.	C) Seminar Type Discussion S) Post Problem Critique	
T & M	9. Discuss how a bow thruster can be used to aid in maneuvering the vessel in tight turns, taking into account own ship's speed and amount of rudder used	9A. Maneuver the VLCC around a tight turn in a channel utilizing a bow thruster 1. 90° 2. 60° to 90° 9B. Use (9A1) and (9A2) with: 1. 15 KTS 2. 6 KTS	C) Seminar Type Discussion S) Post Problem Critique (feedback)	9. Have vessel stopped at predicted position ± meters. S) Remain within 100 feet of the center of the channel

MODULE – MANEUVERING

TOPIC: Stopping a VLCC

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	10. a) Discuss how the following factors influence the ability to to stop a VLCC in the open sea and restricted waters: 1. various displacements 2. various speeds 3. various astern RPM 4. engine time to reserve 5. action of rudder b) Describe the various techniques used to stop a VLCC: 1. in open sea 2. in restricted waters	10. a) Stop a VLCC in: 1) Open sea – original speed of 15 KTS 2) Restricted waters – original speed 10 KTS using each of the following procedures: 1) Rudder cycling stop 2) Coasting stop 3) Full engine reverse 4) J stopping maneuver 5) Crash stop	C) Seminar Type Discussion C) Seminar Type Discussion S) Post Problem Critique for each of the five procedures	S) 1. Maximum stopping distance a) loaded 12 – 13 ship lengths b) in ballast 10 ship lengths 2. Final ship position

TOPIC: Helicopter Transfer

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	11. a) Discuss various characteristics of helicopter operations and their requirements for operations such as: 1. types - single double motors 2. speed - ship and helicopter 3. range - fuel limitations 4. mission - transport of medical cases, personnel or supplies b) Describe operating procedures of underway helicopter transfer as: 1. downwash of air 2. communications - signals 3. courses to maintain 4. approach	11. a) While steaming in coastal waters, maneuver the VLCC as requested by helicopter utilizing the following: 1. proper communications 2. speed changes 3. course changes b) As helicopter hovers, execute a transfer to helicopter while adhering to proper safety precautions.	Textbook review and and critiques with seminar discussion	

MODULE – MANEUVERING

TOPIC: Helicopter Transfer

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	c) Explain safety precautions to observe in transfers relative to: 1. *Static electricity* 2. Hook handling 3. Clear space 4. Proper equipment at hand 5. Personnel coordination			

MODULE – MANEUVERING

TOPIC: Propulsion and Control

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T &	12. Discuss the various types of propulsion as they affect maneuv- large vessels such as: a) diesel electric b) diesel-clutch control c) steam turbine d) turbine electric e) gas turbine 13A. Discuss the various types of engine control for each type of propulsion as it relates to response time and re- liability while maneuvering as: a) bridge control/throttle b) telegraph with engine room control c) clutch arrangements d) change controls. 13B. Discuss the precautions and re- quired delays from one control to another.	12A. Conn the VLCC with power plants listed - (a) to (e) from: 1. ahead 6 KTS to astern 6 KTS using: a. bridge control b. ER control 12B.1. Note the difference in response time from ahead to astern	C) Seminar Type Discussion S) Post Problem Critique for each simulator activity	

CURRICULUM GUIDELINES

MODULE - TUG ASSISTANCE

Objectives:

This module will enable the trainee to develop an understanding of how to effectively utilize tug assistance. Areas to be covered include the following:

Communications
Type of tugs required
Number of tugs needed
Placement of tugs
Methods of securing
Effective power
Berthing or docking assistance
Confined waters assistance
Casualty towing

Preparation:

Review texts such as:

1. Tugs, Towboats, and Towing
2. Knight's Modern Seamanship
3. Review Applicable Rules of the Road - International and Inland

Experience Level:

Large variations of knowledge concerning details of tug assistance are expected, depending on the extent of the trainees previous exposure to tugs use.

MODULE – TUG ASSISTANCE

ACTION BY	TOPIC: Utilizing Tug Assistance CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	1. Discuss the general circumstances when tug assistance is needed by a VLCC such as: Docking Harbor Guidance Open Sea Towing	Utilize tug assistance (see No.6 Simulator) in the following situations: a. Docking b. Harbor Guidance c. Wind 10–20 KT, current 4 KT	C) Illustrations Seminar Discussion S) Post Problem Critique for each section	

MODULE – TUG ASSISTANCE

TOPIC: Rules-of-the Road–Towing

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	2. A) Review Rules of the Road International and Inland as they apply towing for changes to: Lights Shapes Whistles - Signals Action in fog B) Describe localities where tugs are compulsory or strongly recommended.	Use the appropriate lights, shapes, whistle signals when: a) tow astern b) tow alongside c) pushing tow ahead d) all of the above in low visibility	C) Seminar Type Discussion C) Training Aids S) Post Problem Critique for each section	

MODULE – TUG ASSISTANCE

TOPIC: Components

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	3. Survey and discuss factors to consider when selecting components used in tug work such as: Hawsers Wire vs. synthetic Butts Mooring Chain Factory swaging/splices of wire hawsers.	Use the proper components when involved in: a) Casualty towing b) Harbor Guidance c) Docking/Mooring	C) Seminar Discussion and review texts S) Post Problem Critique for each section	Trainee to understand choices

MODULE — TUG ASSISTANCE

TOPIC: Utilizing Tug Assistance

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	4. Evaluate various types of tugboats as to their usefulness in assisting a VLCC. Include items such as: a) Number needed versus effectiveness horsepower b) Type — harbor deep sea—canal	Have each of the following types of assist a VLCC — evaluate their effectiveness a) Harbor and docking tugs b) Coastal tugs c) Ocean going and salvage tugs.	C) Review textbooks and and traing aids S) Post Problem Critique for each section.	
	5. Discuss the types and procedures in communicating effectively with tugboats such as: Whistle signals Bell signals Hand signals Walkie-Talkies Radio telephone Light signals.	In tugboat scenario operation use appropriate types and forms of communications for tugboat maneuvering.		Assure trainee is using proper communication methods and procedures while handling tugboats.

MODULE – TUG ASSISTANCE

TOPIC: Utilizing Tug Assistance

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	6. Evaluate given situations requiring tug assistance with various combinations of tug(s) for: a) Docking b) Channel maneuvering c) To anchor or single point moor.	Show in each instance the: a) Positioning of tug(s) about vessel b) Method of securing, if necessary c) Proper judgement in shifting tugs d) Requesting sufficient H.P. (i.e., No. of tugs) e) Each of the above with different currents up to 4 KTS f) Vary scenario for changing whether vessel has power or dead ship.	C) Visual training aids S) Post Problem Critique for each segment (a–f) of simulator activity	Does trainee show competency in using in using tugboats to safely maneuver vessel?

MODULE – TUG ASSISTANCE

TOPIC: Casualty Towing

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	7. Discuss at-sea towing problems such as: a) Bridles b) Towing arrangement tandom/ single c) Itenary d) Securing on board e) Communications f) Heavy weather g) Poor steerage h) Chafing i) Emergencies 1. Broken towline 2. Taking on water 3. Drifting-lee shore.	Utilize tug assistance when broken down at sea – demonstrate variations or situations of: a) Bridles/ no bridles b) Short/long catenary c) Light/heavily laden vessel d) With various communications between tug/tow e) Broken tow line and retrieval of tow f) Dewatering g) Drifting – more tug assistance	C) Seminar discussion S) Post Problem Critique	Check trainees understanding of forces involved in towing a VLCC and his proper application of tugs.

MODULE – TUG ASSISTANCE

TOPIC: Number of Tugs

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	8. Discuss how many tugs should be used to assist a 170,000 DWT VLCC when: a) Docking with wind of 30 KTS and current of 3 KTS b) Guiding the vessel through the harbor with winds of 20 KTS and current of 5 KTS.	Conn the VLCC using the appropriate number of tugs under the following conditions: (a & b under No. 9 classroom exercises) While conning a VLCC through the channel with 4 tugs assisting, with winds of 20 KTS at bow and a current of 3 KTS, see what effect there would be if: a) Bow tug removed b) Port tug removed c) Stern tug removed d) Starboard tug removed	C) Seminar Type Discussion S) Post Problem Critique for each section	Trainee to demonstrate that he confidently docks or guides VLCC

MODULE – TUG ASSISTANCE

TOPIC: Placement of Tugs

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	9. Discuss where the tugs should be be placed when: a) Docking b) Harbor guidance	A. Dock the VLCC: 1) With a tug on bow 2) Tug on stern 3) Tug on bow and stern 4) Tug on bow, port, and stern 5) Tug on bow, stern and starboard 6) Wind, 20 KTS, current 4 KTS B. Guide the VLCC through the harbor: 1) Conditions same as above.	C) Seminar Type Discussion S) Post Problem Critique for each sub-section (i.e., A-1, A-2, B-1, B-2)	

CURRICULUM GUIDELINES

MODULE - MOORING AND BERTHING

Objective:

This module will provide the pilot/master trainee with a variety of berths and moors which he may be confronted with when docking or anchoring a 170,000 DWT vessel. The trainee will be presented with the interface of the vessel, tugs and specific varieties of berths and mooring combinations so as to provide him with an understanding of how to use the natural and mechanical forces to his advantage.

Preparation:

Review texts such as:

Knight's Modern Seamanship - 16th Edition - Chapter 10
Merchant Marine Officers' Handbook - Chapter 9 and 11.

Experience Level:

It is expected that the trainees' experience level will be generally low in certain topics, due to the normal practice of having the pilot at the conn while mooring or berthing.

MODULE — MOORING AND BERTHING

TOPIC: Winches, Capstans, Ropes

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	1. Discuss the various types of ship's mooring winches and capstans and explain when and how each is used.	Secure the VLCC to a moor using the appropriate winches, capstans, and mooring lines.	C) Seminar Type Discussion S) Post Problem Critique (feed-back)	S) Trainee's use of the appropriate winches, capstans, or mooring ropes
M & T	2. Given various mooring situations, discuss which types of mooring lines should be used and what their arrangement should be.			

TOPIC: Anchoring

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	3. Show, by comparing various size vessels, forces such as momentum and kinetic energy as they relate to anchoring. 4. Discuss the stress on components used in anchoring such as: a) Chain b) Windlass c) Flukes on anchor d) Windlass breaks 5. Discuss the relationship of speed to size.	Anchor and compare the momentum and kinetic energy to overcome before stopping a VLCC with: a) A vessel of 40,000 DWT with a single anchor condition b) Each of the above with speeds of: 1. 0 KTS 2. 1 KT 3. 2 KTS.	C) Seminar Type Discussion S) Post Problem Critique (feedback)	

TOPIC: Anchoring

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	6. Given various mooring or docking situations, discuss anchoring as on aid - show: a) Advantage b) Disadvantages c) Precautions to be used.	Berth a VLCC without tugs or with little tug assistance using anchors: a) Alongside a dock b) In a predetermined position at a roadstead to offload cargo.	C) Seminar Type Discussion S) Post Problem Critique	A) Stopping vessel within 10 feet of berth B) Having anchored $\pm$ 100' of predetermined anchorage position
T & M	7. Discuss differences of procedure when: a) Anchoring in deep water versus shallow water b) Using one or two anchors c) Anchoring with way on or stopped d) Having bulbous bows e) Being equipped with remote control, sensors, TV monitors.	Anchor a VLCC with: a) Deep water b) Shallow water c) One anchor d) With two anchors e) Having way on f) Having no way on g) Using remote sensors and pilot house control.	C) Seminar Type Discussion S) Post Problem Critique for each section of simulator activity	

TOPIC: Bow Thrusters

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	8. Discuss how and when bow thrusters should be used to assist in the berthing operation: a) With tug assistance b) Without tug assistance	Conn the VLCC into a berth: a) Using the bow thruster when no tugs are assisting b) With tug assistance using the thrusters as an asset.	C) Seminar Type Discussion S) Post Problem Critique for each activity (i.e., a and b)	S) 1. Pier closing rate (.05 KT) 2. Ship headway (.05 KT)

TOPIC: Forces Affecting Mooring and Berthing

ACTION ^Y	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	9. Make an advanced plan to show the approach course and the point at which to reduce speed and/or stop engines, in order to avoid making the final landing with too much headway compersating for wind current, tide and loading conditions.	1. Utilize thr dvance plan of approach to execute the berthing or mooring operation under each of the following conditions: a) Going alongside - port side to, being set on to pier fully loaded. b) Going alongside - current from ahead.	C) Seminar Type Discussion S) Post Problem Critique after each simulator activity for numbers 1-5.	Successfully moor or berth the VLCC
T & M	10. Discuss the problems that exist with a single buoy moor and discuss means of overcoming such problems.	2. Going alongside - current from astern, in ballast 3. Clearing a pier - being set off 4. Clearing a wharf - current from astern 5. Moor to a single buoy.		

CURRICULUM GUIDELINES

MODULE - EQUIPMENTS

Objectives:

This module will attempt to broaden the trainees ability to efficiently operate required and optional onboard equipment of a VLCC of 170,000 DWT, given various components and layouts.

Preparation:

Review text - such as:

Dutton's Navigation and Piloting-13th Edition-Chapters 7, 17
Bowditch-1977 Edition

Experience Level:

Most of the trainees should be familiar with the equipments that are presently required, however, variations in ability to effectively operate equipment for a 170,000 DWT vessel are probable.

TOPIC: Electronic Navigation

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	1. Discuss the capabilities, limitations, and areas of applicability of the following hyperbolic systems: a) Decca b) Loran A/C c) Omega Explain how to operate each of the above systems to obtain own ship's position.	Determine own ship's position by operating each of the following hyperbolic systems: a) Decca b) Loran A/C c) Omega 1. Daytime conditions 2. Nightime conditions.	C) Seminar Type Discussion S) Post Problem Critique	

TOPIC: Communication Systems

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	2. Discuss the various internal and external communication systems available on a 170,000 DWT VLCC. Discuss under what situations each type of communications should be used, for example: a. to shore radio telephone b. to shore single sideband c. aboard walkie-talkies d. aboard flag hoists e. aboard blinker lights f. aboard light signals-fixed.	While conning through the channel, use the appropriate means of communication as required in the scenario.	C) Seminar Type Discussion S) Post Problem Critique	

TOPIC: Compasses

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	3. Discuss gyro compass failure and steps to change to hand steering, using magnetic compass.	While conning through the harbor, the gyro fails; effectively change to hand steering using magnetic compass to maintain intended track.	C) Seminar Type Discussion S) Post Problem Critique	Maintain intended track $\pm 2^{0}$

TOPIC: RDF

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	4. a) Discuss the capabilities and limitations of the use of radic direction finders. b) Evaluate various types of RDF's.	4. While proceeding through scenario, utilize the radio direction finder to establish ship's position: a) 100 miles from stations b) 50 miles from stations c) 10 miles from stations.	C) Seminar Type Discussion S) Post Problem Critique	

TOPIC: Controls

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	5A Discuss the capabilities limitations, components and use of: a) ballasting/trim/draft indications b) engine controls c) engine performance - direction d) emergency stop - 1. auxiliaries 2. fuel 3. engines 4. ventilation e) propeller control. 5B Identify all emergency alarms and indicate a preferred corrective action to emergencies such as: 1. shut down component 2. less power 3. anchoring required 4. assistance necessary 5. specific personnel action.	5. a) While conning through the channel, utilize the controls (a-e) as required by the scenario.	C) Seminar Type Discussion S) Post Problem Critique	

TOPIC: Indicators and Dials

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	6. Discuss the capabilities, limitations and applicability of the following indicators and dials: a) turn rate indicator b) rudder angle indicator c) speed indicator d) doppler log e) water depth indicator f) wind direction indicator g) wind velocity indicator h) speed log and distance run i) manual steering j) autopilot.	6. a) While conning the VLCC through the channel, refer to the following indicators and dials (a-j) as deemed necessary to proceed safely through the scenario. b) Evaluate and necessitate/priority performance of each instrument used aboard a VLCC of 170,000 tons. C) Judge whether to disregard or initiate corrective action with ambiguous or unreliable information from any indication as scenario develops.	C) Seminar Type Discussion C) Slides S) Post Problem Critique	

CURRICULUM GUIDELINES

MODULE - CASUALTIES

Objective:

Upon completion of the module, the trainee will be exposed to casualties and will understand procedures to employ in order to minimize damage and recover from them. They should also be knowledgeable as to what authorities to notify and what communications are required.

Preparation:

Review texts such as:

1) Merchant Marine Officers' Handbook - Chapters 16 and 17
2) Basic Ship Theory - Volume I - Chapter 5

Experience Level:

Due to the nature of this module, most trainees will have limited exposure to casualties. This is an area that the simulator will be especially effective as a training tool.

TOPIC: Anchor or Grounding

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	1. Discuss, in general terms, the circumstances requiring the master to abrubtly anchor or ground the VLCC due to casualties such as: a) Loss of power b) Loss of steering c) Collision d) Fire Compare the circumstances of anchoring or grounding above when outside assistance is readily available.	1. If peril is imminent and anchoring or grounding is decided, navigate the VLCC with casualties noted a-b-c-d to an anchorage or ground on a nearby beach.	C) Seminar Type Discussion S) Post Problem Critique	A. Time to reach desired position. B. Accuracy of conning versus projected C. Appropriate own ship's speed, heading, etc.

TOPIC: Minimize an impending Collision

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	2. Discuss the appropriate measures to be taken to minimize damage or loss of life from an impending collision such as: a) How to maneuver for minimizing the impending collision for least damage. b) Sounding of internal alarms c) Watertight integrity d) Checking, if damaged for 1. Water in vessel 2. Structural e) Discuss the forces and kinetic energy involved in a ship-to-ship contact - including mass velocity, area of contact.	2. Maneuver the VLCC defensively to minimize a catastrophe in the event of an imminent collision	C) Seminar Type Discussion S) Post Problem Critique	Adequately minimize the imminent collision.

TOPIC: Communications

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	3. Given various data input and the extent of own ship damage, discuss action to be taken as far as requesting help from external sources: a) What is required by law b) What would be useful to mitigate loss c) Change in navigational lights 1. Inland 2. International	3. Own ship is involved in each of the following casualties - request help from other ships, tugs, and/or Coast Guard as deemed necessary: a) Grounding b) Collision at sea-damage extensive c) Fire d) Oil pollution e) Demonstrate required change in navigational light.	C) Course studies C) Seminar Type Discussion S) Post Problem Critique for each section of simulator activity.	Communications used

TOPIC: Fire on Board

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENTS
T & M	4. A) Discuss the various ship control engineering systems on board the VLCC and their vulnerability to casualties caused by fire, smoke, or toxic fumes. B) Discuss the various types of potential fire hazards that exist on the VLCC such as: 1. Poor wiring 2. Personnel acting improperly C) Discuss how to bring a fire under control, given the location, nature and extent of fire. D) Discuss regulations and equipment required relative to emergencies on board a VLCC.	Given various locations. on board ship, a fire is reported: a) Determine the extent and nature of the fire b) Maneuver the vessel to minimize damage c) Monitor and direct fire fighting efforts d) Decide amount and type of help needed to make necessary communications e) Conditions: 1. Open sea 2. Restricted waters f) Prepare an emergency watch bill for a VLCC.	C) Slides C) Audio Visual Aids S) Post Problem Critique	A. Communication B. Proper fire fighting techniques C. Maneuvers made

TOPIC: Man Overboard

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	5. Discuss, in a man overboard situation, what the best maneuver would be if the following conditions existed: A) Open Sea 1. Unlimited visibility, calm seas 2. Visibility less than 1NM, sea state 4 3. Unlimited visibility, winds of 20 KTS, sea state 4. B) Restricted Waters 1. Channel width 700', unlimited visibility 2. Channel width 1200', visibility less than 1NM 3. Unlimited visibility, channel width 1200', calm seas. 6. Discuss the proper communications to use in a man overboard situation. 7. Discuss the effects of wind and sea on small boat deployment. How would such conditions affect the maneuver made?	For a man overboard situation, under the following conditions, maneuver the VLCC to recover the man as well as remain clear of other vessels: A. Open Sea 1. Unlimited visibility, calm seas 2. Visibility less than 1 NM, sea state 4 3. Unlimited visibility, winds of 20 KTS, sea state 4. B. Restricted Waters 1. Channel width 700', unlimited visibility 2. Channel width 1200', visibility less than 1NM 3. Unlimited visibility, channel width 1200', calm seas. Utilize appropriate communication and proper deployment and recovery of lifeboats.	C) Seminar Type Discussion S) Post Problem Critique for each section of simulator activity (i.e., A-1, B-3).	Maneuver made to recover man overboard Communications used

TOPIC: Flooding

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	8. Discuss the effect on the trim and stability of an intact ship in the event of damage to and consequent flooding of a compartment as well as the counter measures to be taken.	8. Damage and consequent flooding of a compartment occurs. Take the appropriate counter measures to ensure ship safety and personnel safety.	(C) Seminar Type Discussion (S) Post Problem Critique	Perform the appropriate compensatory measures.

TOPIC: Environmental Pollution

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	9. Discuss the IMCO requirements as they are laid down to restrict or totally prevent pollution in certain areas of the sea, particularly those close to land or in harbors and in land-locked seas such as the Mediterranean. 10. Discuss what the VLCC must do with their waste products if in restricted areas.		C) Seminar Type Discussion	

TOPIC: Inoperative Navigational Aids

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	11. Using a chart of Port XYZ and given a certain location in the channel, discuss what navigational aids or range structures could be substituted if a range malfunction is determined or if a navigational aid or range structure is missing.	Conn the VLCC through the channel, without deviating from the intended track when: a) One or both range structures are obscured on certain bearings b) One structure is missing c) Some buoys are missing due to storm d) Some buoys are out of position e) Range structures masked visually and from radar by other structures or natural features on an intermittent basis.	C) Seminar Type Discussion S) Post Problem Critique for each section of simulator activity	Maintain position 100' from center of channels Navigational position error of $\pm$ 100 yds

TOPIC: Rudder Failure

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	12. Discuss the compensatory measures for each of the following types of rudder failures: a) Loss of electrical power b) Rudder jamming of mechanical systems c) Loss of rudder (i.e., drop off).	12. A) On a VLCC which is underway in a channel, decide what course of action to follow and then initiate this action to reduce damage with the following types of rudder failure: 1. Loss of electrical power 2. Rudder jamming 1) 25^0 left rudder 2) 25^0 right rudder B) Complete A-C with the following conditions: 1. Single screw propeller 2. Twin screw propeller C) Using anchors, power from eng[illegible]es or tug assistance.	C) Seminar Type Discussion S) Post Problem Critique of each section of simulator activity.	Perform the appropriate compensatory measures to maintain ship control

MODULE – CASUALTIES

TOPIC: Propulsion Failure

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	13. Discuss the procedure used to overcome a propulsion failure on a VLCC with: a) Single screw propeller b) Twin screw propeller c) Controllable pitch propeller d) Failure of throttle control	Demonstrate effective action to restrict damage of a failure of the propulsion on a VLCC while in a channel when the VLCC has: 1) Single screw propeller 2) Twin screw propeller 3) Controllable pitch propeller under the following conditions: 1) Traffic – 5 contacts 2) Winds – 15 KTS 3) Current – 2 KTS 4) Throttle control cooperative	C) Seminar Type Discussion S) Post Problem Critique for each section of simulator activity.	Perform the appropriate compensatory measures to maintain ship control.

TOPIC: Electrical Failures

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	14. Discuss the various types of electrical failures that could occur on a VLCC which could affect ship control.	Conn the VLCC through the channel when any electrical failure affecting ship control occurs such as: a) Rudder indication b) Radar (in poor visibility) c) Gyro d) Etc.	C) Seminar Type Discussion S) Post Problem Critique for each section of simulator activity	Perform the appropriate compensatory measures to maintain ship control

TOPIC: Communication Failure

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	15. Discuss the consequences of communication failures that could occur such as loss of: a) VHF b) Whistles c) Running lights d) Walkie-Talkies e) Internal phone systems and describe an alternate method of communication.	Conn the VLCC through the channel when each of the following types of communication are required but are inoperative: a) VHF b) Whistle c) Running lights d) Walkie-Talkies e) Internal phone systems Compensate by using an alternate method of communication.	C) Seminar Type Discussion S) Post Problem Critique for each section of simulator activity	Perform the appropriate compensatory measures

CURRICULUM GUIDELINES

MODULE - LOCAL HARBOR CONDITIONS

Objectives:

A discussion of specific conditions and rules that may exist or be enforced in "Port XYZ" will be presented and discussed to acquaint the trainee with limitations he may experience while approaching or navigating any harbor. These conditions or restraints would be similiar to those found in many ports. The trainee will be provided with enough examples of these harbor situations to have him confidently decide how to maneuver with these problems. Some of the items to be covered will be:

- Anchoring regulations or areas
- Channel speed/wake/blockage restraints
- Safety fairway - traffic separation
- Freshets - seasonal weather
- Dredging - partially blocked channels
- Recent wrecks in channel
- Concentration of vessels - pleasure/commerical/military
- Night movements
- Pollution considerations
- Unusual seasonal tides
- Extreme weather
- Ice
- Communications/vessel/controllers
- Bridge opening schedules
- Holidays-strikes-Longshoremen hours.

CURRICULUM GUIDELINES

MODULE - NAVIGATION

Objectives:

Upon completion of this module the trainee should be able to develop quick solutions to the following routine piloting chores:

a) identify aids to navigation
b) current problems - predictions of events
c) tidal problems - predictions of height and times
d) radar plotting in varying visibility and courses
e) gyro to magnetic courses
f) mental estimating of speed and ETA's - calculations for predicting turns and time to various ETA's
g) improve skill in planning of events in harbor navigation

Materials Required:

1) chart of Port XYZ
2) tide and current tables
3) a coast pilot with Port XYZ
4) navigational tools - dividers, pencils, parallel rulers, triangle, clock, stopwatch
5) radar PPI scope - maneuvering board equipment
6) Bridge outlay with regular gear - compasses
7) chart table - operational fathometer and settings by trainee
8) operational parameters of 170,000 dwt VLCC

Preparation:

Give the trainee time to assimilate and become familiar with the materials listed above (i.e., various charts and publications) which will be available on the simulator and in the classroom. Point out local or temporary changes and hazards that differ from those listed on the chart.

Overall Conditions:

Discuss with trainee courses, channel characteristics, and the harbor layout. Advise the trainee that realistic situations (run in "real" time) exist and that different conditions may be introduced from the given information to ascertain alertness, response time, and corrective action. Mental problem solving to give quick results will be required.

Situations and conditions of navigation varied by harbor traffic and visibility will not be considered in this module. They will, however, be included in the Integrated Ship Handling Module.

Experience Level:

Many of the details of this module will be familiar and practiced by the trainee. Specific problem areas are expected in the conning problems.

TOPIC: PLOTTING - TURNS

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	1. Using information on the chart and the VLCC characteristics, predict where course changes should commence. Give the bearings and ranges from objects and aids used. 2. Discuss how this maneuver will be affected by change of speed or current.	1. At maneuvering speed, navigate the vessel as per predictions without variables on: A. Turn of 45^0 B. Turn of 75^0 C. Turn of 120^0 D. Repeat A-C, introducing a head current of 2.5 KTS E. Repeat A-C, introducing an astern current of 2.5 KTS F. Repeat A-C using a vessel speed of 7 KTS.	C) Seminar Discussions S) Feedback Critique after each turn completed.	S) Compare and evaluate actual deviation from course predictions, $\pm$ feet.

TOPIC: CURRENT PREDICTIONS

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	3. Determine set and drift of current, the stage of tide, and ETA and channel depth: A. Sea Buoy B. Intermediate position (approximately halfway between harbor entrance and berth) C. Intended Berth	3. At maneuvering speed, navigate the vessel through the channel, compensating for set and drift and taking into account channel depth at any given point under the predicted tidal conditions.	C) Direct exposure (work through) S) Overall feedback Critique	

TOPIC: MAN-MADE VARIATIONS TO THE ENVIRONMENT

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	4A From the chart, point out and discuss areas of the harbor where wake, suction or bank effects will be a factor in maneuvering and where slow speeds would be prudent to avoid damage. 4B Discuss how to compensate for the effects caused by: a) interaction between passing ships b) interaction between own ship and nearby banks.	4A Conn the vessel through various legs of the channel compensating for, minimizing, or taking advantage of: A. Wake B. Bank Effects C. Suction 4B Maneuver the vessel in a passing situation through the waterway, compensating for the suction caused by the two passing ships.	C) Seminar Type Discussion C) Direct Exposure (work through) S) Post Problem Critique for each section of simulator activity.	(S) Actual deviation from intended track ± feet and difference from ETA. (S) Remaining within ± feet from center of channel.

TOPIC: ANCHORAGES

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	5. Indicate where preferred anchorages are, if necessary to anchor because of fog or breakdown. 6. Select the appropriate courses and navigational aids to fix the ship's position en-route and locate the turning bearing points.	5. Navigate the VLCC into an appropriate anchorage & anchor.	C) Seminar Discussion S) Overall feedback critique	S) 1. Accuracy of final position ± FT 2. Turn position

TOPIC: DAY/NIGHT NAVIGATION

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	7. Describe the major differences in navigating at night as compared to navigating during the day.	7. Navigate the vessel, at maneuvering speed, through the channel: a. during day b. at night	C) Seminar Discussion S) Overall feedback Critique for each section of simulator activity	S) Deviation from intended track ± FT

TOPIC: NAVIGATING TO PILOT STATION

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T	8. Determine course and speed to use from a star fix to arrive at the sea buoy (pilot station) at a particular ETA, taking into account the set of a given current.	8. *Navigate the VLCC using* the determined course and speed to arrive at the Pilot Station and pick up the pilot on time.	C) *Seminar - pro*blem solving S) Overall feedback Critique	S) 1. Vessel is lined up and slowed to less than 3 KTS at the Pilot Station 2. Actual ETA versus predicted ETA 3. Keep vessel toward the channel $\pm 20^0$ of course for 3 minutes at slow speed so as to pick up pilot.

TOPIC: USE OF COMPASS

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	9. Discuss procedure for determining gyro error. Explain how to correctly use a magnetic compass to determine course if the gyro fails.	9. Use dependable navigational aids such as ranges and course line ups, for determining compass error.	C) Seminar Discussion S) Post Problem Critique	Accuracy of calculation

TOPIC: RADAR PLOTTING

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	10. Discuss the affect of visibility when radar plotting, to determine a fix.	10. In a relatively open stretch of the harbor, request the trainee to plot a fix from radar information and establish an ETA to berth: a. Visibility - .5 NM, 3 NM	C) Seminar Type discussion S) Post Problem Critique	Accuracy of plot and ETA $\pm$ Min. time to give fix x sec

TOPIC: Conn to Berth

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	11. Discuss how to assess the accuracy of a position fix when using bearings in conjunction with charts, notices to mariners and other publications.	11. Conn the VLCC to the berth, using bearings from landmarks and aids to navigation, in conjunction with appropriate charts, notices to mariners and other publications to assess the accuracy of the resulting position fix.	(S) Overall Feedback Critique	(S) Compare ETA to time off berth. Check trainee's alertness to vessel off course or change in speed due to current.

TOPIC: NAVIGATE USING SUBSTITUTE AIDS

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
T & M	12. Discuss, for a particular position in the channel, substitute navigational aids that can be used if others are missing or if a range malfunction is determined.	12. Conn the VLCC through a channel without deviating from the intended track, when the navigational range structures available for various channel legs have one or both range structures obscured on certain bearings.	C) Seminar Type Discussion S) Post-Problem Critique (feedback)	S) Maintain position 100' from center of channel.
T & M	13. Discuss procedure for navigating in poor visibility when buoy spacing is inadequate for existing conditions.	13. Conn the VLCC through the channel when buoy spacing is inadequate for existing poor visibility conditions.	C) Seminar Type Discussion S) Post-Problem Critique	S) Maintain position 100' from center of channel.

TOPIC: Avoidance Maneuvers

ACTION BY	CLASSROOM EXERCISE OR DISCUSSION	SIMULATOR ACTION OR ACTIVITY	METHODOLOGY	PERFORMANCE MEASUREMENT
M & T	14. Specify various obstacles or hazards that exist in Port XYZ, along with the location of each. Discuss various avoidance maneuvers to safely conn the VLCC around such obstacles. 15. Discuss the practical measures to be taken when navigating through ice or when there are conditions of ice accumulation on board.	14A Perform an avoidance or diversion maneuver in the channel to avoid shoals or large rocks that are located in close proximity or within the confines of the channel. 14B Conn the vessel to avoid a shoal or a wreck in the vicinity of the channel entrances. 14C Conn the vessel in restricted waters avoiding the following navigational hazards: a. cables b. pipelines c. breakwater 15 Maneuver the vessel through the channel a. navigating through ice b. when there is an accumulation of ice on board.	(C) Seminar Type Discussion (S) Post Problem Critique for each section of simulator activity.	(S) Maintain proper distance from the obstacle, proportional to channel configuration.

CURRICULUM GUIDELINES

MODULE - INTEGRATED SHIP HANDLING

Objective:

This module will complete the transition training of the master/pilot. A complete scenario will be presented which would require the trainee to utilize all the previously discussed techniques as well as the learning experiences gained from ship handling on the simulator.

In this module, the simulator will be programmed with the capability of introducing any combination of previously reviewed conditions.

The trainee shall anticipate and be prepared to respond appropriately to any variable presented. The trainee shall expect that any variable presented may be modified at any time during the progress of the scenario.

The scenario will be a continuous run from a position at sea through a harbor with channels and traffic to berth with a constant review by the monitor. Freezing of the progress and partial re-run will be introduced as necessary for emphasis. The variables to be presented at various times, will consist of combinations of the following:

1. Varying degrees of visibility from fog or weather conditions
   - a) 0-1 mile
   - b) 2-5 miles
   - c) unlimited
2. Channel width
   - a) 700'
   - b) 900'
   - c) 1200'
3. Channel depth
   - a) 50'
   - b) 70'
   - c) 80'

CURRICULUM GUIDELINES

MODULE - INTEGRATED SHIP HANDLING

4. Ship traffic

   a) None
   b) Light (1-5)
   c) Medium (6-10)
   d) Heavy (over 10)

5. Wind - Any relative direction at speeds of:

   a) 0-10 KTS
   b) 10-20 KTS
   c) 20-30 KTS
   d) 30-40 KTS
   e) 40-50 KTS
   f) over 50 KTS

6. Current - Any relative direction at speeds of:

   a) 0-1 KT
   b) 2-3 KTS
   c) 4-5 KTS

7. Tide

   a) 0-5 FT
   b) 6-10 FT
   c) 11-15 FT
   d) 16-20 FT

8. Own ship speed

   a) 0-5 KTS
   b) 6-10 KTS
   c) 11-16 KTS
   d) 17-20 KTS

CURRICULUM GUIDELINES

MODULE - INTEGRATED SHIP HANDLING

9. Loading conditions

   a) Light
   b) Fully loaded
   c) Ballast

10. Time of day

   a) Day
   b) Night
   c) Dusk
   d) Dawn

11. Sea states

   a) 0-3
   b) 4-5
   c) over 5

12. Obstacles or hazards

   a) Islands
   b) Rocks
   c) Shoals
   d) Ships anchored adjacent to or in the channel
   e) Fishing boats engaged in fishing
   f) Buoy tenders - dredges
   g) Work under construction
   h) Cables
   i) Pipelines
   j) Overhead power lines
   k) Breakwater
   l) Ice

CURRICULUM GUIDELINES

MODULE - INTEGRATED SHIP HANDLING

13. Sharp bends and turns in channels
    a) Greater than 90^{0}
    b) 60^{0} - 90^{0}
    c) Less than 60^{0}

14. Single casualties
    a) Rudder failure
    b) Propulsion failure
    c) Bridge electrical failure
    d) Gyro failure
    e) Radar failure

15. Propeller
    a) Single screw
    b) Twin screw
    c) Controllable pitch

16. Maneuvers
    a) Docking
    b) Mooring
    c) Anchoring
    d) Turns
    e) Stopping

17. Channel configurations
    a) two cross channels
    b) three or more cross channels
    c) Y channel

CURRICULUM GUIDELINES

MODULE - INTEGRATED SHIP HANDLING

18. Possible collision situations

    a) Crossing (stand-on/give-way)
    b) Ambiguous (stand-on/give-way)
    c) Overtaking (stand-on/give-way)
    d) meeting head on

19. Casualty situations

    a) Fire on board
    b) Flooding
    c) Collision
    d) Grounding
    e) Man overboard.

EXHIBIT D-3

DIAGNOSTIC ANALYSIS SCENARIO

SIMULATOR SCENARIO

M/T*	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
1D	0	Master-trainee at conn, inbound toward sea buoy 4 miles out at maneuvering speed 14.5 KTS. Course Sea State - Moderate Wind force 3-4 South Visibility-light fog Current-3 KTS (Easterly) Loaded condition-draft 50 FT.	Master	Navigation Instruments Chart Radar	Have vessel at 3 Knots upon arrival at sea buoy.	± .3 Knot
4B		a) Slow vessel b) As necessary conn vessel		B) Have vessel on course.	B) Keep vessel within 50 YDS of center of lane.	
11F 11B	1	Show correct course to steer.	Mate to Master	Chart and navigation equipment	Chart course ± 1^{0}	
11F	2	Predict ETA at sea buoy.	Mate to Master	Chart and navigation equipment	ETA within 2 minutes	Should arrive at sea buoy no later than 28 minutes

* Module/Topic

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
1B	3	Determine Rules-of-the-Road Boundary Lines at its ETA.	Mate to Master	Chart and Sailing Directions or Coast Pilot	a) Time to calculate and b) Time of ETA	
8D 11F	4	Check ships position.	Mate	RDF/or Fathometer/or Radar	a) Plot vessel on chart within time period b) Accuracy	a) + 2 minutes b) ±.2 miles
5E	5	Maintain Course.	Master-Helmsman	Steering Gear	Have Vessel on course.	Keep vessel within 50 YDS of center lane.
2D 1C	6	Send/Receive communication from pilot (i.e., "What side ladder and weather at station").	Master	UHF Radio	Terminology Phrasing Format	Satisfactory/ Unsatisfactory

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
2B	7	Determine velocity and direction of current at sea buoy.	Interaction between Mate and Master.	Current tables Chart	a) KNOTS b) Direction Degrees	$\pm$ .1 KNOT $\pm$ 10°
—	8	Continue conning.	Master	—	—	—
2B	9	Vary current velocity to 1 KNOT.	Master - Mate	Simulator/Radar (Some reference background useful for "eyeball" check)	Note response time of person conning.	+ 2 minutes
1E	10	Introduce vessel fine on port side 8.5 miles out on 2nd leg.	Interaction between Master and Mate.	Simulator/or CAS Radar	Note alertness of person/s on bridge.	
	11	Continue conning.	Master		Lookout capability	
11B	12	Determine height of tide at berth at + 2 hours (approximate time to berth) from 12th minute.	Mate to Master.	Tide tables with chart	Height Feet	0(-) .1 FT

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
1E	13	Check-Decide traffic problem. If a threat exists, determine CPA and time CPA.	Master and/or Mate	Radar-CAS or plotting	Determine threat	
8G	14	Check that pilot is clear and stand by personnel are ready.	Mate to Master	Internal communications	Satisfactory Unsatisfactory	
2E 1C	15	Receive/Send ship-shore phone. Pilot gives caution about thick fog.	Master	VHF	Phrasing and format	
2E	16	Fog becomes dense, call additional bridge personnel.	Inter-action between Master and Mate	Internal Communications Simulator	a) Time to order vessel slowing down b) Time to take over radar plotting	Check speed if reasonable
1A					c) Note whistle (fog) signals- do they change when in inland waters.	

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
11H	17	a) Check ships position b) Determine new ETA c) Show pilot boat at sea buoy.	Mate to Master	Radar/chart or Fathometer		
1C	18	Advise pilot of new ETA.	Master	VHF	Terminology Format	
	19	Conn vessel.	Master		Check if within channel tolerance.	
11H	20	Decide when to come to slow and whether to turn right for lee for pilot boat.	Master	Decision making	Is vessel at prudent speed.	0-3 KTS.

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
1D 5A 5D 11A	21	Enter turn in round-about traffic scheme.	Master Helmsman	Judgement between rudder and steering gear.	Ability to anticipate maneuver smoothly - considering turning circle.	
1I 1G	22	Vessel ahead slows - own vessel meeting.	Radar Officer to Master	Simulator Radar/ CAS	Time to note response to traffic Check CPA	
19 1C	23	Send/receive message to oncoming vessel of passing intentions.	Master	VHF channel	Is proper Rules of the Road and communication format used.	
11F	24	Appropriate arrival at pilot station.	Master	Judgement	Decision to turn vessel for lee for pilot boat.	Vessel at pilot station and aligned properly.

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
3A 5C	25	Pilot takes conn-lines up in channel to breakwater - possible increased speed.	Pilot-Master Mate	Engine Order telegraph	Vessel heading Master to Pilot "Handoff" information passing.	Is vessel properly lined up and on proper course Dialog between Master-Pilot
8B 1C	26	Pilot in contact with ashore ship routing - vessels name, draft, size and cargo. Give position ETA to breakwater ETA to Berth speed - now (fog slow) maneuvering Advise of impending traffic.	Pilot	VHF	Format and completeness	

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
5D	27	a) Steady vessel on 025° toward breakwater b) "Rough" compass check.	Pilot Master Helmsman	Helm	Time to steady vessel - amount off course line	
1I	28	Update and inform Pilot/Master of vessel ahead.	Radar Mate/ Pilot and Master	Radar CAS	"Smoothness" of routine, transmit of information	
1I 1G	29	Other vessel approach now imminent	Pilot	Radar CAS		Is clearance between vessels sufficient.
11H	30	Determine position of vessel	Radar Mate/ Mate on Watch to Pilot and Master	Radar/chart Simulator shows breakwaters	Check difference from course line and distance off breakwater	
2B	31	Change current to westerly 2 KNOTS 2 tugs off breakwater		Simulator	Note attention of pilot/master conning	

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
6E	32	Pilot in contact with tugs - advises arrangement 1 forward starboard/ headline 1 aft port quarter - 2 lines	Pilot	UHF (Garble with tugs conversation)	Phrasing and format	
6E	33	Advise Mate(s) of tug lashing.	Pilot to Master to Mates	Walkie-Talkies	Clarity and smoothness of making one understood.	
		Check position	Mate on Watch	Radar	Course revision - to counter change of current.	
9I	34	Engine Room calls overheated shaft Must shut down.	Mate to Master to Pilot	Engine Room Phone Engine Room Telegraph Tachometer	Note reflex of personnel to casualty	

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
6E 1C	35	Pilot advises tugs to respond quickly 1 forward starboard 3 "lines" 1 aft quarter 2 "lines"	Pilot Master Mate	UHF	Note amount of "Confusion". Do all personnel react professionally and individually?	
9A		Master revises orders to Mates-Mate forward to re-check anchors.		Walkie-Talkie		

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
1B 1I	36	Pilot retains vessel heading Master/Mate May change signals/ lights Fog out of command.	Pilot Master Mate Helmsman	Helm	With current checked, can he do it with no propeller action	
	37	Pilot contacts shore-side authorities.	Pilot	VHF	Completeness	
	38	Master advises Berth personnel.	Master	VHF	Note discussion and change of channels	

SIMULATOR SCENARIO

M/T	Time Minute	Situation	Personnel Response	Equipment Used	Performance Measures	Acceptance Criteria
	39	Tugs securing	Pilot - Master to Mates	VHF Walkie-Talkies	Does vessel respond to tugs?	
	40	With two tugs vessel guided through breakwaters.	Pilot Master Tugs	VHF Radar Walkie-Talkies	Show vessel lined up between breakwaters.	

APPENDIX E

TRAINING SIMULATOR SYSTEMS

E.1 INTRODUCTION

Phase 1 objectives of the Certification and Training Project are to:

a. Compile task analysis data to identify tasks performed by a licensed deck officer.

b. Identify skills and knowledge necessary to perform those tasks.

c. Identify factors which influence the level of skill and knowledge required.

d. Delineate simulator use to develop and demonstrate those skills.

e. Identify factors affecting feasibility of using simulators to improve and demonstrate mariner skills.

f. Delineate issues which require further investigation.

Appendix E is oriented toward achieving objectives d, e, and that portion of f pertaining to simulator system design. In support of Phase 1, Appendix E identifies issues relevant to the design of a training simulator system and its integration with stipulated training specifications.

E.2 METHODOLOGY

Appendix E integrates software requirements (specific functional objectives) with cost effective hardware selection to delineate comprehensive training simulator design requirements.

The structure and validity of the training program are addressed in other portions of this report. However, since the training simulator system design is the means by which the training program is implemented, this design must be coordinated closely with specific functional objectives (SFOs). The integrating of SFOs and training simulator system design requires a step-by-step procedure that defines and evaluates simulator state-of-the-art training effectiveness and relative cost factors. This process is illustrated in FIGURE E-1 and discussed below. The paragraphs are numbered to correspond with the illustration.

(1) Data Base

Simulator system design must include inputs from widely diversified sources of information. Accordingly, a threefold approach was used, incorporating (a) observations of simulators, (b) a literature search, and (c) comprehensive discussions with personnel in the field.

Existing simulators in operation were observed to gain insight into the practical aspects of simulator utilization. An operating simulator (CAORF) was visited on numerous occasions

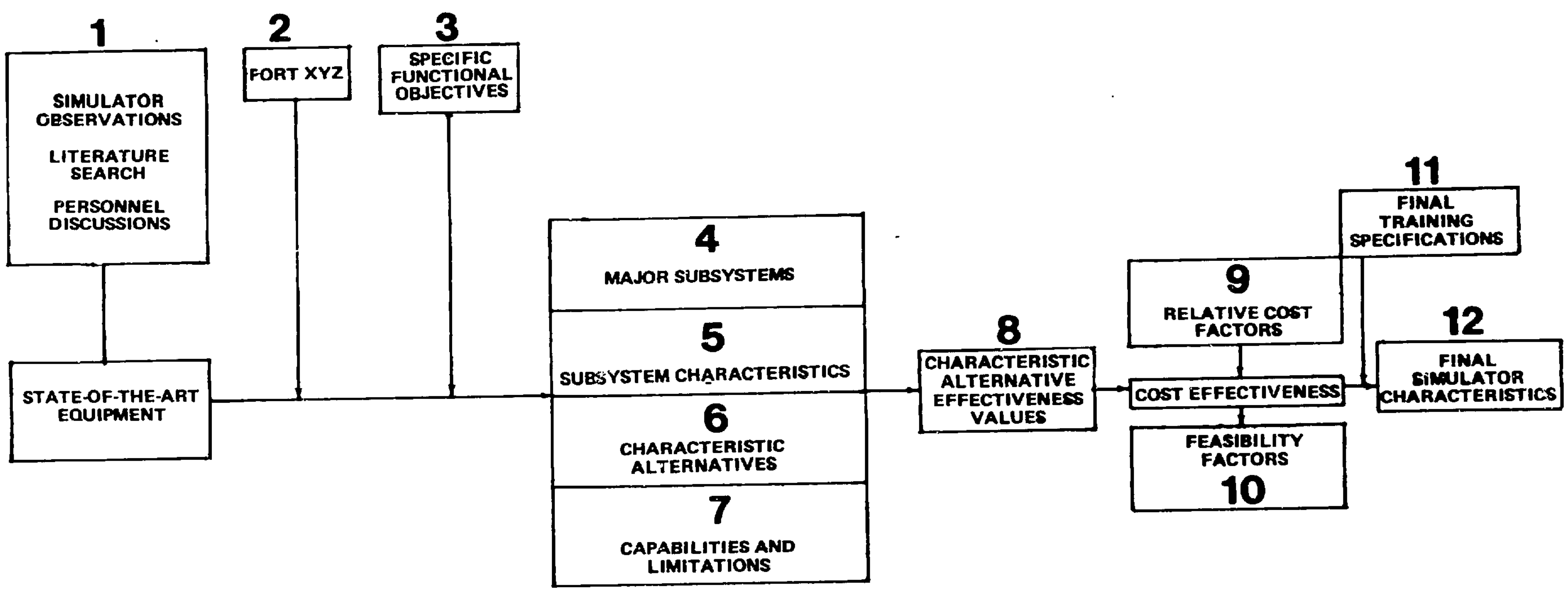

Figure E-1. Process of Simulator System Design

to examine:

a. Operation of the simulator.

b. Functional subsystem technical capabilities and limitations.

c. Methods of data collection and evaluation.

d. Observer/instructor/subject (trainee) relationships.

e. Present simulator applications for both training and research.

f. User (trainee) acceptance of the simulator environment.

g. Performance measurement and evaluation.

This information is incorporated in Exhibit E-1.

For the literature search, numerous basic texts and research papers were examined by personnel in the human factors, behavioral training, and merchant marine fields to establish a comprehensive data base of information on existing simulators and their characteristics.

Comprehensive discussions were also conducted with licensed merchant mariners (masters, mates, and pilots), human factors personnel, behavioral training specialists, and technical systems personnel. Each group provided the required expertise to supplement the information gathered during the literature search. The compendium of information from both sources was the basis for development of Exhibit E-2.

These combined sources as reflected in Exhibits E-1 and E-2, represent the state of the art for simulator equipment.

(2) Port XYZ

Characteristics of a hypothetical port, Port XYZ, were examined thoroughly to provide the basis for training program specifications and simulator system requirements. These characteristics were used to develop specific harbor representation requirements in the proposed simulator subsystem design. Port XYZ characteristics are discussed further in Appendix A, Exhibit A-3.

(3) Specific Functional Objectives

The SFOs (listed in Appendix A, Exhibit A-8) were examined to determine the applicability of simulator system design and to evaluate the effectiveness of system characteristic alternatives.

(4) Major Subsystems

Simulator systems currently available were subdivided into twelve major subsystems, on a functional basis, in order to provide a practical means of correlating specific simulator capabilities with the SFOs. This process was necessary to establish cost effective training simulator design requirements. The objective is to provide the experienced mariner with an effective simulator environment commensurate with his training requirements. The major subsystems are further discussed in Exhibit E-2.

(5) Subsystem Characteristics

The twelve major subsystems were divided into functional primary characteristics so that alternatives could be selected to meet training requirements and assist in performance measurement. These characteristics are based on the trainee's perception of specific training conditions. Exhibit E-3 provides a detailed subdivision of these characteristics under their respective subsystems. For example, under Visual Image Display are the characteristics of color, field of view, day/night, own ship motion, contact motion, and type of exercise area.

(6) Characteristic Alternatives

The subsystem characteristics have been further subdivided to:

a. Allow flexibility for the type of training required (e.g., navigation, rules of the road, shiphandling.)

b. Provide a capability for various methods of performance measurement

c. Itemize various environmental elements necessary for realistic accomplishment of the training objectives.

d. Provide flexibility in training various skill levels

e. Accommodate expansion into team training.

f. Incorporate the state-of-the-art hardware technology commensurate with the availability of the desired components.

g. Provide a means for comparison of alternatives presently found in existing simulators.

The effectiveness of a training simulator system is determined by user (trainee) acceptance of its capabilities and limitations in representing the user's environment. Training simulator characteristic fidelity is a compromise among cost, state-of-the-art hardware availability, and stipulated SFOs. Simulator system fidelity and characteristic alternatives are discussed in Exhibit E-3. Specific characteristic fidelity levels and natural environmental conditions are compared in detail in Exhibit E-7.

(7) Characteristic Alternative Capabilities and Limitations

Each characteristic alternative was further subdivided to determine its capabilities or limitations, and was evaluated only in the specific training areas where it had major impact. Exhibit E-3 provides a comprehensive recapitulation of these capabilities and limitations keyed to the major subsystems and their characteristic alternatives.

(8) Characteristic Alternative Effectiveness Values

Early in the hardware evaluation stage of this study, it became critical to provide a method for quantitatively evaluating the characteristic alternatives to complete the training objectives. A method was devised to provide an individual effectiveness coefficient value to quantitatively measure each alternative's relative ability to demonstrate/train a given SFO. This value was derived only in relation to other alternatives within the same system characteristic; e.g., "color" was evaluated in relation

to "black and white", but not to "field of view". Exhibit E-4 presents this information in matrix form with a detailed explanation of the process for calculating the numerical rating system.

⑨ Relative Cost Factors

One of the overriding elements constraining the simulator system designer is the available financial resources of the builder. Quantum leaps in technological development, resulting in possible cost reduction in technical hardware, have been more than offset by increasing labor, construction, and maintenance expenditures. Exhibit E-5 discusses in detail training simulator system characteristic cost factors.

⑩ Feasibility Factors

The detailed training system design is constrained by the training specifications, financial resources, physical plant size, location, and portability. Since these factors are usually fixed, it is imperative that the scope and level of training be determined before the training simulator system design is finalized.

⑪ Final Training Specifications

To control costs and be most effective, final training specifications must be determined before the training simulator design is finalized. The design must be flexible enough to permit training of various skill levels at varying degrees of complexity in the same time period, thereby increasing the number of trainees and reducing the per unit cost.

⑫ Final Simulator Characteristics

Every effort must be made to optimize training simulators to accomplish the required training specifications cost effectively. Flexibility can be increased by the coordinated use of part-task simulators and classrooms in conjunction with more sophisticated simulators. The part-task simulators are particularly useful in the training and/or reinforcement of fundamental skills. The sophisticated simulator can then be used to integrate these skills and provide a training medium for sophisticated application of the more complex training objectives, thus enabling the mariner to attain the proficiency levels required on a day-to-day basis. Exhibit E-6 represents a simplified ideal for a simulator design for training of the skills required of today's mariner. The matrix was developed after close examination of the skill and knowledge requirements contained in the SFOs. Skill levels were then determined and the appropriate simulator was delineated.

E.3 RESULTS AND DISCUSSION

The analysis of training simulator systems was based on the following assumptions;

a. The skill levels and areas of training should apply to all licensed deck officers. Any expansion or deletion of the training objectives may directly affect the configuration of the training simulator system.

b. The hardware state of the art and the availability of components should remain relatively stable during the initial system design. Should any extensive developments occur in the areas of cost or additional technological improvements, the system design should be thoroughly re-examined.

c. Although cost is of utmost importance to the designer of a training simulator system, subsystem characteristic alternatives have first been technically evaluated independent of cost factors. Cost factors are addressed in Exhibit E-5 and should be considered in the final cost effective tradeoff analysis.

Results are discussed in detail below.

E.3.1 General

General findings are itemized below. Details are discussed in Sections E.3.2 through E.3.8.

a. Complete detailed substantive data was not available on the cost of simulator design and construction parameters or specific training objectives of individual simulators.

b. Examination of the detailed information contained in Exhibit E-2 shows that effective training simulators are presently being utilized throughout the world.

c. The individual effectiveness of these existing simulators is a function of the training objectives imposed on the simulator.

d. Considering the constraints imposed by specific characteristic alternative capabilities and limitations described in Exhibit E-3, training simulators can effectively accommodate the training of mariner skills, provided the selection of the stipulated training objectives is within those constraints.

e. The training simulator characteristic alternatives delineated in Exhibit E-3 are predicated on an extended simulator life and possible expansion of the scope of training over and above that outlined in the SFOs.

f. The flexibility of the proposed simulator system design may provide a capability for training manipulative as well as decision making skills. Exhibit E-6 demonstrates the capability of the various devices to train those skills.

g. As described in Exhibit E-6, simulator system design can provide training in multiple skill levels in the same time period. These various skill levels may be included in specific training objectives in basic, refresher, or transition training.

h. The discussion contained in Exhibit E-7 regarding fidelity issues of certain characteristic alternatives emphasizes the ability of a simulator system to represent the natural environment.

i. User acceptance of fidelity levels can be assisted by strict definition of training objectives as embodied in the SFOs. For example, the lack of a visual subsystem should not degrade the usefulness of part-task simulator whose purpose is to train radar plotting.

   User acceptance of simulators may be evaluated based on:

   1. Realism/fidelity
   2. Training objectives

(a) Need

(b) Acquisition of skills and knowledge

(c) Improved performance

3. Instructor competence

4. Maintainability, reliability, and accessibility

5. Add-on capability for

(a) New state-of-the-art equipment

(b) Updating to meet new training requirements

(c) Additional flexibility (such as different ship types and additional harbor representations)

Early input to simulator design by potential users can facilitate user acceptance of the end product by providing a better appreciation of the requirement for specific fidelity levels to support the user's training objectives.

E.3.2 Major Subsystems

The major functional subsystems were developed to provide a training simulator system that could effectively accomplish the stated training objectives. In addition, these functional subsystems can be easily translated into hardware requirements to permit cost effective evaluations to be made. Twelve functional subsystems were chosen as those best able to represent the functional attributes perceived by the trainee within the context of the training situation. They are:

a. Subsystem 1: Visual image display

b. Subsystem 2: Visual image generation

c. Subsystem 3: Radar/collision avoidance

d. Subsystem 4: Bridge equipment configuration

e. Subsystem 5: Audio

f. Subsystem 6: External factors

g. Subsystem 7: Motion base

h. Subsystem 8: Control mode

i. Subsystem 9: Facility arrangement

j. Subsystem 10: Own ship characteristics and dynamics

k. Subsystem 11: Own ship malfunctions

l. Subsystem 12: Training assistance technology

Subsystems 9 and 12 do not directly affect the trainee in the simulator environment. However, they have been included because of their impact on simulator training effectiveness in general. Proper ancillary facilities, with a minimum of mutual interference and providing a maximum performance measurement capability, are an integral part of an effective training simulator system.

The degree of subsystem utilization is directly related to the fidelity of the training simulator and the creation of a realistic marine environment. For example, own ship motion can be represented visually, utilizing certain image generation and display systems. However, to provide a greater degree of realism, a motion-based subsystem could be added which would stimulate the trainee's vestibular sense. This is a prime example of how the degree of simulator fidelity can be enhanced by the integration and coordination of the various subsystems. Exhibit E-3 discusses the impact on the vestibular and kinesthetic senses by the motion base subsystem and the possible effect on training effectiveness.

E.3.3 Subsystem Characteristics

The ability of the twelve major subsystems to support the stipulated training objectives is predicated on their amenability to a further subdivision by functional characteristics. Exhibit E-3 provides a detailed breakdown of these characteristics.

The proper integration of these characteristics provides maximum flexibility for the systems designer to provide a cost effective training simulator system capable of meeting previously determined specific training objectives.

Technological development in computers, projectors, and control systems is proceeding rapidly. As a result of the literature search and technical discussions previously mentioned, the subsystem characteristics selected represent the latest state of the art. The capabilities and limitations discussed in Exhibit E-3 are based on this technology.

E.3.4 Subsystem Characteristic Alternatives

Applying the capabilities of existing state-of-the-art hardware to these alternative characteristics, Exhibit E-3 was developed. The objective was to examine each alternative and its possible interrelationship with other alternatives.

Detailed study of Exhibit E-3 clearly indicates that there are numerous combinations of subsystem characteristic alternatives. The selection of these combinations of alternatives will have a marked influence on the ability of the training simulator to carry out the stated training objectives.

Expected changes in the utilization of the training simulator must be considered in training simulator design. The design must be capable of accommodating physical expansion, change in usage (e.g., training to certification) and curriculum expansion to include new areas of training and/or trainee skill levels.

In the research/investigation phase of this task, it became apparent that data from controlled experiments was lacking. Exhibit E-2 shows that training simulators throughout the world have a multiplicity of system characteristic alternatives, but there does not appear to have been a cohesive effort to evaluate and validate the relative efficiency of the various alternatives in conjunction with finitely structured training objectives. In the majority of cases, it appears that the design of the training simulator was based on cost considerations and the training objectives were then tailored to meet the training simulator capabilities. This, of course, results in a severe limitation of the training simulator capability and may even inhibit future expansion of the physical facilities as well as the broadening of the training objectives. If the selection of simulator system components is being considered, engineering system compatibility is of utmost impor-

tance. Engineering control, indication, and mechanical interface problems may occur in critically designed subsystems.

E.3.5 Alternative Characteristic Effectiveness Coefficients and Cost Factors

Delineation of the specific characteristic alternatives is only the first step in defining training simulator design parameters. It is evident that without specific training objectives and well defined training simulator capabilities, the inclusion or exclusion of certain alternatives may result in the design of an inadequate training simulator which may not meet the desired objectives. Delineation of the training capabilities from the broad spectrum of skills contained in the SFOs provides proper direction to the training effort and allows for the necessary quantitative judgments to be made regarding the selection of alternative training simulator designs.

Exhibit E-4 provides the method of rating the overall ability of the alternatives to perform the specific training objectives, following the step-by-step procedure delineated in Section E.2. An analysis of the matrix contained in Exhibit E-4 indicates that many of the alternative characteristics previously considered to be indispensable in a training device could possibly be supplemented by a less costly alternative or perhaps by accepting a lower level of fidelity with minimal loss of training efficiency. As a corollary, any lessening of training efficiency in one subsystem characteristic may possibly be supplemented by use of a characteristic from a different subsystem to provide the capability to complete the training objective. Consideration of the effectiveness coefficients in Exhibit E-4 provides insight for viable alternatives of simulator design such as the use of a part-task trainer for training certain skills contained in the SFOs. Characteristic alternatives of comparatively equal average effectiveness coefficients represent areas for additional research to determine where realistic cost tradeoffs can be made.

Analysis of Exhibit E-4 indicates several subsystem characteristic alternatives where effectiveness coefficient differentials are very small but cost differentials very large. Use of an arbitrary differential of 2.5, which is approximately 20 percent of the maximum differential possible, allows certain alternatives to be readily isolated for investigation. FIGURE E-2 delineates representative examples which reflect this 20-percent differential. The first characteristic alternative listed is the least efficient as denoted in Exhibit E-4. The cost factors are displayed in the same order as the alternatives. Some characteristic alternatives (e.g., CRT resolution) that are less desirable and more costly should not, however, be automatically rejected. Future expansion of training areas and skill requirements may require this alternative, thus making it ultimately more cost effective to provide it initially and avoid future cost increases.

E.3.6 Training Simulator Definition

Exhibit E-6 represents a simplified ideal for the training of skills required of today's mariner. The feasibility of the use of any or all of these training simulators is constrained by such parameters as cost, physical plant size, location, portability, and training objectives. The scope and level of training must be determined prior to the finalization of the design of the training simulator system. Expansion of the scope of the training requirements over the expected life of the training simulator system should also be considered.

ALTERNATE	RELATIVE EFFECTIVENESS DIFFERENTIAL	ESTIMATED COST RATIO
VISUAL DISPLAY SYSTEM		
System Characteristics		
Black and white versus color	2.4	1.0:2.0
Day versus day/night	1.2	0.9:1.0
Horizontal Field of View		
±90° versus ±120°	1.7	0.6:1.0
±120° versus 360°	1.4	1.0:2.0
Vertical Field of View		
±10° versus over ±10°	1.2	1.0:>1.0 (dependent on horizontal field of view)
Own Ship Motion		
2 axes and rotation versus 3 axes and rotation	0.9	1.0:1.3
Contact Control		
Fixed track versus pre-programmed	0.7	0.5:0.7
Pre-programmed versus flexible control	2.1	0.7:1.0
Resolution		
10–20 arc minutes versus less than 10 arc minutes	1.6	0.5:1.0
Luminance		
Less than 5 fL versus 5–10 fL	1.9	0.7:1.0
5–10 fL versus 10–20 fL	0.5	1.0:1.5
Contrast Ratio		
Less than 25% versus 25%–50%	1.4	0.4:0.6
25%–50% versus 50%–75%	1.3	0.6:0.8
50%–75% versus over 75%	1.9	0.8:1.0

Figure E-2. Effectiveness/Cost Relationship

ALTERNATE	RELATIVE EFFECTIVENESS DIFFERENTIAL	ESTIMATED COST RATIO
VISUAL IMAGE GENERATION SYSTEM		
Image Source		
Single point versus model board	2.5	0.35:0.6
Model board versus CGI	2.5	0.60:1.0
Image Rejection		
Back lighted versus front lighted	2.0	1.2:1.0
Screen Configuration		
Rectangular versus curved	1.0	0.6:0.7
Curved versus cylindrical	2.5	0.8:1.0
Projected Control		
Preset versus computer controlled	1.3	0.5:1.0
Computer controlled versus instructor controlled	1.2	1.0:0.7
RADAR/COLLISION AVOIDANCE SYSTEM		
Color		
Monochromatic versus multichromatic	1.6	1.0:1.5
Contact Motion		
Stationary versus 1 axis	0.5	0.2:0.6
1 axis versus 2 axes	2.5	0.6:1.0
Radar Bearing Coverage		
±90° versus ±120° from bow	1.9	1.0:1.0
±120° versus 360°	1.5	1.0:1.0
CRT Resolution		
Less than 10 arc minutes versus 10 – 20 arc minutes	1.7	1.6:1.0

Figure E-2. Effectiveness/Cost Relationship (Cont'd)

Exhibit E-6 addresses the problem of integrating part-task training simulators and classroom facilities with a full bridge simulator. The associated matrix reflects the training areas where these simulators are considered most effective. In some instances part-task simulators and/or classrooms may be used independently; while in other situations, the part-task simulator may become a valuable adjunct to the full bridge simulator. The variety of skills embodied in the SFOs addressed in Exhibit E-6 clearly indicates that any expansion of the scope and/or level of the training effort would put an ever increasing burden on the facility. Effective utilization of part-task simulators could provide the required flexibility cost effectively.

The following paragraphs define the role of each portion of the training simulator system and provide substantive support for the matrix assignments.

Classroom. The supplementary use of classrooms, particularly with the use of audio/visual aids, can provide valuable assistance in accomplishing the specific training objectives. Some representative advantages are:

a. Equipment components can be demonstrated without interfering with part-task simulator utilization

b. Theoretical subjects (e.g., ship dynamics, ship characteristics, equation of motion) can be presented for any level of training

c. Update training in Rules of the Road, radar and visual plotting, collision avoidance, and relative motion can be accommodated

d. Specific harbor familiarization and trip planning can be accomplished

e. The number of students of the facility can be expanded by:

   1. Alternating groups or individuals between training simulators and classrooms

   2. Providing flexibility in training various individual skill levels in the same time period

f. Meeting/seminar discussion areas are available free from interference of other activities

g. The training simulators are available for more advanced study and/or training

h. Initial instruction in the techniques of maneuvering for control casualties can be provided prior to practical application on the training simulator.

Part-task Simulators. The capability to conduct individualized multiple level training in a given time period is a valuable simulator advantage. The simultaneous training of various skill levels may broaden the trainee base and improve the cost-per-unit ratio.

Part-task simulators are invaluable in providing training to a large number of mariners in manipulative skills required by many bridge operational procedures, particularly below the master/pilot level. The add-on capability of the numbers and/or type of simulators to meet expanding needs makes this alternative most attractive. New state-of-the-art equipments can be added and obsolete components eliminated without disrupting the operation of the main full bridge simulator. In addition, a tie-in capability with the operation of the full bridge simulator can provide an opportunity for additional personnel to participate simultaneously in certain phases (e.g., radar piloting and collision avoidance) of a full bridge simulator scenario in progress.

Economy in personnel and operating costs can also be realized by the use of part-task simulators. The per hour cost for each trainee can be lowered by increasing the number of trainees performing any particular task while decreasing the number of instructors/operators required. Certain skills can also be trained without the use of the full bridge simulator which can then be utilized for more productive tasks in the training/certification area.

Full Bridge Simulator. The full bridge simulator while more complex and consequently more costly than the part-task simulator provides many options not available from the supplementary facilities:

a. Individual and team training as required

b. Integration of the skills and knowledge developed by the supplementary facilities

c. Realistic setting for true representation of ship response under a variety of conditions

d. Full flexibility of scenarios

e. Capability for equipment degradation and/or casualties

The many options available in this training device, particularly as it may apply to transition training from smaller to larger ships, makes it more than just a viable alternative to at-sea platforms. The full bridge simulator can provide once-in-a-lifetime training opportunities that the average mariner may never experience in his many years at sea, situations which may turn into disaster without immediate corrective action.

Full bridge simulators can provide unique training opportunities which would not be available to the sea-going mariner through on-the-job training. Effectiveness in this regard hinges upon the recognition of certain factors which impose constraints on at sea training:

a. Operational expense

b. Safety

c. Lack of opportunity or repeatability

d. Availability of vessels

e. Operating schedules

Certain skills, however, such as celestial navigation, damage control, and small boat handling can be practiced at sea on a continuing basis without the need for frequent referral to shorebased facilities for additional training. The skills contained in the SFOs which are best accomplished on the at-sea platform have been addressed.

E.3.7 Representative Subsystem Characteristics

One of the measures of success of a training simulator is its ability to represent a given training situation in a most realistic manner. User acceptance primarily rests with this ability of the training simulator to represent operational situations realistically. In particular, an experienced mariner may be negatively influenced if the exercise conditions do not closely approximate the at-sea conditions to which he is accustomed. The

inexperienced trainee may also incur negative transfer of training if the training conditions and the training equipment utilized are not equivalent to those found at sea.

While the at-sea platform may not be the most efficient training device, it does present training opportunities for the mariner in a natural environment. Therefore, it may be advantageous, from a transfer of training viewpoint, to have the simulator represent the environment, stimuli, vessel, and equipment characteristics to the fullest extent possible dependent on the stipulated training objectives.

a. Real Environment. One of the most effective means of achieving training simulator fidelity is to represent environmental factors, such as wind, rain, snow, fog, and waves with both visual and auditory cues. These environmental factors may be further enhanced by other major device subsystems such as platform motion. The magnitude of the stimuli from each subsystem must be equivalent so that the total effect is consistent. A sea state of 9 with a 5-knot wind is one example of an unrealistic environmental situation.

b. Real Stimuli. In the simulator, most of the stimuli received by the trainee are either visual or auditory. Exhibit E-7 compares the characteristics of the visual and audio subsystems with natural stimuli ranges and limits. The state-of-the-art capability to meet these ranges exists in most instances. The addition of other stimuli, such as the vestibular sense from a motion base subsystem can provide reinforcement of the perceived situation and simulator fidelity is further enhanced.

   One of the natural visual characteristics not presently met by visual simulators is resolution. Exhibit E-7 indicates that under normal conditions the human eye has a resolution of 1 minute of arc. At the present time the best visual image (other than single light) that can be simulated is about 3 minutes of arc. This deficiency results in blurring, wavering, and lack of detail in certain types of image representations.

   Until the state of the art is able to overcome these deficiencies, other characteristics can be utilized to mask or disguise the deficiency and increase fidelity. For example, poor image resolution can be masked with variable atmospheric conditions such as haze or fog. It is evident that the greater the alternative flexibility, the greater the capability of the training device to achieve the training objectives.

c. Real Ship. This term refers to the ability of the training device to represent the total at-sea platform including ship maneuver response and realistic bridge arrangement. Any drastic differences from the real ship, particularly as to maneuver response may completely negate the training objective. This would be particularly true in the case of transition training from a smaller to larger class of vessel.

   Fidelity in this area is directly related to the ability of the training device to reflect the equations of motion of the actual ship either from trial results or from the extrapolation of a mathematical model. Delayed response to wheel and engine orders also adds to this realism and may reflect the true ship characteristics of an unfamiliar class of ship for a trainee undergoing transition or basic training. (See Exhibit E-4.)

   An additional method for increasing ship fidelity is to provide a means to improve variable equipment casualties. The SFOs concentrate on these

casualties and their effect on exercise scenarios. Most existing training devices have an "OFF-ON" capability, but variable casualty situations are not readily available. "Variable casualty" reflects the ability of the training device to limit or expand the degree of malfunction so that operational situations can be improved or degraded based on action taken by the trainee. (See Exhibits E-4 and E5.)

d. Real Equipment. One of the fundamental objectives of mariner basic training should be the ability to operate, read, and interpret onboard equipment and its associated indicators. It is possible to provide operational exercise information to the trainee by the use of simulated equipments. However, if actual equipment must be used at sea, a certain degree of negative training will occur from use of simulated equipments in the training simulator. The degree of simulation (i.e., number of components as well as method of presentation) will have a direct effect on the amount of negative training imparted.

E.3.8 Training Methods and Techniques

Exhibit E-3, Section 12, "Training Assistance Technology" is a comprehensive outline addressing training techniques and methodology which can be utilized by simulator systems of varying degrees of complexity. It correlates the varying aspects of the subsystem characteristics and their ability to provide a capability to perform various training techniques and performance measurements. Training simulator systems can be designed to provide the capability for utilization of certain training techniques. This is particularly true in the role of the part-task trainer (e.g., radar plotting and repetitive exercise techniques of varying degrees of complexity for drill purposes).

E.4 CONCLUSIONS AND RECOMMENDATIONS

An effective training simulator design must be cost effective and meet the required training objectives. The previously used "shotgun" approach in design and construction of training simulator systems is no longer feasible in this age of rising costs and specialized areas of training. "Bigger" is not necessarily "better" and the sophisticated designer is the one who tailors his design to training needs and available resources. Conclusions and recommendations, which reflect this basic principle of training simulator system design, follow.

E.4.1 General

1. Very little objective, controlled experimental data defining simulator training capabilities currently exist. Section E.5 is a list of possible research issues relating to the simulator's compatibility for training identified SFOs.

2. During the MARSIM '78 symposium, it was reported that acceptance of marine simulators by masters, mates, and pilots as useful tools for training certain mariner skills was at a high level. The validity of this statement is evidenced by the continued usage and upgrading of existing marine simulators and the construction of new simulators in Great Britain and Norway (as documented in Exhibit E-2). The advantage of a ship maneuvering simulator is that it provides a safe, economical, readily available environment for training mariner skills.

3. The training effectiveness of a simulator may be considerably enhanced when the simulator design provides for training of manipulative as well as decision-making skills. Exhibit E-6 presents specific examples of the types of skills involved (e.g., radar plotting, navigation plotting, ship tracking, and relative motion analysis).

4. The SFOs defined for this study require a high level of manipulative skills. Inclusion of the part-task simulators defined in Exhibit E-6 within the total training simulator design provides flexibility to fulfill the SFOs at the required manipulative skill level.

Lamb, Bertsche and Carey (Aug 1970) have previously established the validity of the approach of a generalized ship simulator encompassing part-task simulator subcomponents to train decision-making and manipulative skills. Their conclusions were applied to a submarine advanced casualty ship control simulator, but appear equally applicable to a marine simulator as discussed in this report.

5. The effectiveness of simulator design is reflected in its capability to accommodate both present and anticipated SFOs. Future SFOs may involve increased levels of training or new areas of endeavor (such as certification). Possible future training needs should be studied before the simulator design is finalized so that evaluation of the required characteristic alternatives can be an integral part of the initial simulator design process.

6. The training program/simulator characteristics relationship should be constantly re-evaluated during the initial design phase. Unforeseen changes in hardware technology or financial resources can impact program definition considerably. Periodic program re-evaluation during the simulator design phase would enable these changes to be carefully integrated in the final product.

7. Simulator capabilities vary widely throughout the world as a function of the multiplicity of simulator characteristics. Concomitant with variations in simulator characteristics (albeit not necessarily proportional) are variations in cost and training effectiveness. A detailed cost analysis should be made of worldwide simulators. This analysis should include operation, maintenance, initial design, and construction costs.

8. As detailed in Exhibits E-3 and E-4, the natural environment can be variously represented by a simulator. For example, image projection and generation systems can represent such visual attributes as visibility, image clarity, surround brightness, sea motion, bow waves, and ship wakes. The level of representation necessary can be determined by investigating the issues listed in paragraph E.5.

9. Examination of Port XYZ parameters indicates that the simulator system characteristics delineated in Exhibits E-2 and E-3 will support the representation of specific geographic harbor areas if required by the training objectives. The degree of representation can be in accordance with the stated SFOs. Further investigation is needed to determine if the capability to represent specific harbor configurations is required.

10. Existing maritime simulators are constrained by their characteristic's capabilities and limitations as outlined in Exhibit E-3. The training objectives which may be accomplished may be severely limited by simulator subsystem definition. For example, a lack of a visual subsystem will impact the ability of the simulator to train in visual navigation and certain visual aspects of collision avoidance. In another area, lack of a capability to portray traffic ship motion would seriously impact the ability of the simulator to conduct collision avoidance or rules of the road training.

E.4.2 Major Subsystems

11. The methodology used to define the major simulator subsystems can be applied in other areas such as training specifications or scenario development.

12. Certain subsystems have the capability of supplementing or substituting for other subsystems cost effectively. For example, own ship's motion may be simulated in the visual subsystem in lieu of providing a mechanical motion-based platform. Feasible, cost effective subsystem substitutes or supplements should be further investigated.

13. The different characteristic alternatives chosen in a simulator design may markedly affect the ability of the simulator to meet the specific functional objectives. Furthermore, elimination of even one subsystem may degrade the ability of the simulator to train in several specific areas. For example, if target motion in two axes with target rotation were not included, radar tracking, collision avoidance, and relative motion training could not be conducted. The characteristic alternatives must therefore be chosen at the proper levels of fidelity to support present and future training objectives.

14. A high percentage of deck officer shiphandling SFOs are supported by the technological capabilities of existing hardware as shown in Exhibits E-1, E-2, and E-3. Subsystem components should therefore be selected to provide the level of fidelity required by the SFOs. Refinements in individual component designs should be pursued to provide multiple alternatives for the simulator designer.

15. One of the effectiveness measures of a simulator is its ability to provide a transfer of training to the real world. Discussions in Exhibits E-3 and E-7 show that where manipulative and interpretive skills are involved, subjective evaluation indicates that actual rather than simulated equipments should be used to promote effective transfer of training. Objective data should be collected to determine both the relative training and cost effectiveness of actual versus simulated equipment.

16. The specific characteristic alternatives selected in this report to support the SFOs vary widely in training effectiveness, cost, and cost effectiveness.

a. Training effectiveness (see Exhibit E-4). The characteristic alternatives evaluated vary widely in their ability to complete the SFOs. Overall effectiveness values (Exhibit E-3) range from 0.3 (e.g., no equipment malfunctions) to 12.2 (e.g., flexible instructor control of contact movement). Additional experimental data should be obtained before finalizing simulator design. As noted in paragraph 1 of this section, very little data exists; refer to Section E.5 for a list of possible research issues.

b. Cost (see Exhibits E-4 and E-5). The characteristic alternatives diverge widely in cost. On a percentage basis, the alternatives vary from 40 percent of the reference alternative (e.g., horizontal field of view of ±60 degrees from bow versus ±120 degrees from bow) to 300 percent (e.g., visual display of black and white versus color). The information displayed in TABLES E-4-2 through E-4-11 and discussed in Exhibit E-5) reflects relative cost factors. Before selection of any simulator characteristic alternative, absolute costs should be determined. These costs should reflect any up-to-date information that may affect the design and construction of the finalized simulator.

c. Cost effectiveness. The cost effectiveness of specific characteristic alternatives is determined by the ratio of training effectiveness to the cost factor. An increase in fidelity, for example, results in a corresponding increase in cost. The simulator designer must decide whether the training specifications warrant the more expensive alternative or whether a less expensive alternative will suffice. As mentioned previously, certain subsystem characteristics can be utilized to fill a training requirement which may permit the deletion or downgrading of a characteristic in a separate subsystem. Thus, cost effectiveness tradeoffs must be accomplished by considering the simulator as a whole and not by viewing each subsystem individually.

17. While the range of overall effectiveness values for the characteristic alternatives is broad, for a substantial number (approximately 30 percent) of alternatives, the effectiveness differential is 20 percent (2.5) or less as listed in FIGURE E-2. It is recommended that these alternatives be evaluated on a cost effective basis after final selection of the training objectives to:

a. Establish the potential need for simulator training versus other types of training.

b. Identify priorities for each SFO with cross-reference to the training system characteristic alternatives required to achieve each objective.

c. Identify viable simulator characteristic alternatives for high priority SFOs to eliminate alternatives that would produce an unacceptably low level of effectiveness.

d. Evaluate each of the viable alternatives on a cost basis, eliminating those beyond realistic funding limits.

18. Costs to be evaluated in simulator cost analyses include:

a. Initial design and construction costs.

b. Life cycle operating and maintenance costs.

c. Equipment replacement costs, both for replacement with similar equipment and with advanced state-of-the-art equipment.

d. Add-on capacity

E.4.3 Training Simulator Definition

19. Part-tasks simulators are an important adjunct to full bridge simulators in that they can:

a. Train manipulative and decision-making skills, freeing the more sophisticated full bridge simulator for more complex training tasks.

b. Decrease the cost per trainee ratio by training a number of trainees in the same time period and reducing the instructor/trainee ratio substantially.

c. Train individual skills which may later be applied in the bridge environment on either an individual or team training basis. Bertsche et al (1970) indicate that this approach to cost effectiveness has been successfully applied to other areas of shiphandling training (submarine ship control casualty training).

The final selection of SFOs should be evaluated to determine the relative effectiveness of part-task and full bridge training simulators to accomplish the training objectives. They should also be evaluated to determine those SFOs which may properly be trained by other means, such as classroom instruction or on-the-job training.

20. Use of classroom rather than simulator training, whenever appropriate, reduces the simulator workload and increases training flexibility by:

a. Increasing the number of trainees that can be accommodated through alternate classroom/simulator scheduling.

b. Allowing the operation of equipment components to be demonstrated without impacting simulator availability.

c. Permitting instruction in the theoretical aspects of shiphandling.

d. Providing the capability for training different skill levels in the same time period (e.g., basic skills group in the classroom; intermediate, in the part task simulator; and advanced, in the full bridge simulator).

Use of alternate classroom/simulator scheduling also increases the number of trainees using the full and part-time simulators in any one time period, thereby decreasing the cost per trainee hour.

E.4.4 Simulator Realism

21. The level of simulation fidelity, although a contributing factor, is not always positively related to training effectiveness. The level of fidelity required may vary by SFO. The fidelity levels of the individual parts of the training simulator system should reflect that required by the training objectives, with a reserve capacity to support other potential areas of training effort.

22. The fidelity level of a training simulator may not be selected properly because of a lack of preselected SFOs. The potential user of the training simulator should be an informed participant in the selection of simulator fidelity levels so that those levels will meet the requirements of his training objectives.

23. The training simulator should have the capability to automatically produce the degree of fidelity required for a given teaching condition or level of the training objective (e.g., levels of luminance, resolution, and contrast in a "twilight" situation). Therefore, if the sophistication of the training simulator permits, automated instructional functions should be available to provide the desired fidelity for a given teaching condition.

24. The level of characteristic fidelity may definitively affect trainee acceptance of the simulator and consequently the training effectiveness of the simulator. Fidelity levels should not degrade or destroy the primary training objectives.

25. Since no objective experimental data define the impact of fidelity (realism) on the assimilation and evaluation of information and the resultant decision-making process on the part of the trainee, this aspect of training should be investigated.

E.4.5 Training Assistance Technology

26. The many training techniques available in a simulator system must be carefully assessed as to their applicability to the SFOs when determining the training simulator system design. Training simulator systems should be designed to facilitate the training methods best suited for the training objectives involved.

27. Part-task training simulators can be particularly effective in providing the proper device for a specific training technique and thus should be utilized to the fullest extent possible to achieve the objectives stated in paragraph 26.

28. The ability to record, play back, and rerun exercises and/or demonstrations, either totally or in segments, is a valuable training simulator system capability for immediate repetition and postproblem critique training techniques. As such, these capabilities should be provided to facilitate full utilization of these techniques.

29. The training simulator should incorporate proven methods for performance measurement. The training simulator design should provide the capability to measure individual performance and, if required by the training objectives, team decision-making capability.

30. Data taking to support training methods should be automated to maximize the quality of the data and to release training personnel for more efficient utilization of their expertise in the training process. It is thus recommended that the training simulator provide an automatic data taking capability to the extent required by the stated training objectives, with the capability for expansion to support new areas of training if required.

E.5 RESEARCH ISSUES

Following is a list of research issues relating to the simulator's compatibility for training identified SFOs. The list is grouped by descending priority into three categories. Items within categories are necessarily listed in order of priority.

Category 1. Top Priority Research Issues

The relative effectiveness of

a. Color versus black and white

b. Varying degrees of horizontal field of view

c. Day versus night

d. Ship contact motion versus stationary contacts

e. Symbol versus other visual representation of contact aspect

f. Various numbers of ship contacts

The interactive effects of resolution, luminance, and contrast on image presentation.

The level of fidelity of the equation of motion necessary to represent own ship characteristics (such as block coefficient, propeller slippage, shallow water, and bank effects).

Category 2. Medium Priority Research Issues

The relative effectiveness of

a. Use of lights versus shadow images in a nocturnal setting

b. Simulating own ship's motion (e.g., pitch: $\pm 5^{\circ}$, roll: $\pm 5^{\circ}$, heave: $\pm$6in.) and selecting the proper subsystem to be used in the simulation (e.g., visual versus mechanical motion base)

c. Depth perception cues simulated by texture, black and white shading, and color shading

d. Actual versus simulated equipments such as Loran, radios, pelorus, and indicators

e. External versus internal audio subsystem (e.g., ship signals, bell buoys, and diaphones versus ventilation blowers, engine noise, and radio "chatter")

f. Variable versus fixed (e.g., zero or unlimited) visibility

g. Fast versus real time

h. Part-task versus full bridge simulators

i. A remote instructor's station versus one within the wheelhouse area

j. A separate simulator control station versus one integrated with the instructor station

k. Various methods of instructor monitoring of trainee action (e.g., direct versus indirect, audio versus video)

The cost effectiveness tradeoff regarding the mix of part-task simulators, full bridge simulators, and classrooms.

The advantages of providing or not providing the following training assistance technology:

a. Data recording

b. Data reduction

c. Observation/monitoring

d. Performance measurement

e. Problem control

f. Long term storage library for statistical performance data, individual performance data, scenario routines, and feedback displays and information

The degree of richness (detail) of the visual field and the relative percentage mix of details (e.g., landmass, NAVAIDS, building structures) required to fulfill the SFOs.

Definition of the minimum range to effectively complete mooring and docking SFOs.

Category 3. Lower Priority Research Issues

The relative effectiveness of

a. Varying degrees of vertical field of view

b. Bow wave and wake representations for visual cues for speed and direction of own ship and contact ships

c. The visual field versus a mechanical motion base to represent own ship's motion

d. Various sizes (e.g., less than 25 sq mi, 25-625 sq mi, and greater than 625 sq mi) and types (e.g., open ocean, coastal waters, harbor waters) of exercise areas

e. Various types of image projectors (e.g., slides, movies, and TV) and image generation systems (e.g., model boards and computer-generated images)

f. Environmental factors (e.g., rain, fog, and snow) to provide flexible scenario conditions

g. Portraying actual versus hypothetical harbors or ports

h. Preplanned programs versus individual instructor control for

- Contact motion
- Environmental conditions
- Scenario events
- Stress conditions
- Alarms

i. Radar/collision avoidance system performance degradation by environmental causes (e.g., sea return, land clutter, rain squalls)

j. Manual versus automatic steering

k. Delayed response (e.g., inertia, hydrodynamic effects, operator "dead" time) versus instantaneous response for the steering and propulsion systems

l. A small versus a large bridge, considering factors such as overall installation size, projection techniques, image clarity and parallax, and accommodation of required equipment

m. Optical aids (e.g., binoculars and pelorus) versus alternative information sources for information collection under varying full bridge simulator parameters (e.g., screen radius, image acuity, and image parallax)

The effectiveness of having the capability to simulate

a. Thrusters

b. Anchor control

c. External hydrodynamic factors (e.g., set and drift and sea state)

d. Dynamic tug forces

The effectiveness of the following system's components

a. Navigation information collecting (e.g., RDF, radar, Loran, pelorus, fathometer, and doppler log)

b. Position plotting (e.g., plan position indicator/repeater, dead reckoning tracer, and chart table)

c. External communications (e.g., UHF/VHF radio transceiver, walkie-talkie, radio weather facsimile receiver)

d. Internal communications (e.g., telephones, general announcing systems, and electronic intercom)

The effectiveness of providing a

a. Start/restart capability at variable scenario points

b. A freeze capability at variable scenario points

c. Video, audio, and computer data recording

The effect on transfer of training of the selection of bridge configurations and component hardware.

The fidelity required for mathematical modeling of objects in the visual field.

The advantage of broadening the training base by providing the simulator capability to train malfunction control in steering, propulsion, radar/collision avoidance, electric power systems, and ship control indicators.

EXHIBIT E-1

EXISTING SIMULATOR CHARACTERISTICS

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EXISTING SIMULATOR CHARACTERISTICS

This exhibit delineates existing simulator hardware state-of-the-art. A data sheet has been compiled for each of the major simulators world-wide so that each one can be assessed individually. Tables E-1-1 through E-1-4 have been compiled to allow comparison of the simulators.

SIMULATOR DATA SHEETS

SIMULATOR FACILITIES
SUMMARY CHARACTERISTICS

NAME:	CAORF/NMRC Computer Aided Operations Research Facility
LOCATION:	Kings Point, New York
DESIGNER/MANUFACTURER:	Sperry Systems Management Division of Sperry Rand
COMPUTER TYPE:	Dual SEL 85, general purpose, 32 bit, 176K core
OBJECTIVE:	Research
OPERATIONAL STATUS:	January 1976
BRIDGE SIZE:	4.3m depth, 6.1m width

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Computer generated image, 5 Eidophor projectors, 18.3m diameter cylindrical screen, 4.0m height

FIELD OF VIEW
240° horizontal; $+10^{\circ}$ -14° vertical

SIZE OF GAMING AREA(S)
Visual 50 x 100 nm includes: New York Harbor; Valdez 50 x 50 nm; Santa Barbara Channel (Point Conception) 60 x 120 nm; open sea, Louisiana, Florida, Puget Sound, Santa Cruz Channel

VISUAL DETAILS
Color or black/white, day/night, fog, NAVAIDS, topographical features, resolution: 3.6 arc minutes

SIMULATION CAPABILITIES

OWN SHIP
80,000 dwt tanker load/ballast; 165,000 dwt load/ballast, 250,000 dwt load/ballast, 280,000 dwt load/ballast, 15,000 dwt cargo ship loaded; 125,000 cubic LNG loaded, 35,000 dwt.

TARGET SHIPS

RADAR: 40 targets; landmass, $\pm$ 35 arc ft

VISUAL: 6 ships (at one time), 12 different ship types

SOFTWARE
Wind (shifts and gusts), current, tug forces, depth (New York Harbor), shallow water effect (limited) for 80,000 dwt (1.3 to 1 depth to draft ratio); docking to within 15.2m of pier, passing ship effects, bank effects

CONTROL
Malfunctions (propulsion, steering, electric power), target ship control, computer audio/visual, record/playback/freeze

NAME: Ship Maneuvering & Research Simulator of the Institute TNO for Mech. Construction

LOCATION: Leeghwaterstraat 5, P.O. Box 29, Delft, The Netherlands

DESIGNER/MANUFACTURER: Institute TNO for Mech. Construction at Delft TNO-IWECO

COMPUTER TYPE: Digital EAl Pacer-100, general purpose, 16 bit, 32K core

OBJECTIVE: Research & Training

OPERATIONAL STATUS: April 1968

BRIDGE SIZE: 4.5m depth, 3.5m width

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Shadow graph single point light source (cut-out 3-D) flat translucent screen (10m width, 3m height), backlighted, 3 buoy projectors

FIELD OF VIEW
120° horizontal; extension to 270° - 360° is possible, 28° vertical

SIZE OF GAMING AREA(S)
Open sea - no restrictions, coastal area - diameter 18nm, harbor area - diameter 5nm

VISUAL DETAILS
Color or black/white, day/night, fog, buoys, landmarks, lead line, own ship projected separately. Europort harbor, moving water, surface, clouds, resolution: better than 1 arc minute.

SIMULATION CAPABILITIES

OWN SHIP
Fully loaded 250,000 dwt VLCC (2); 545,000 dwt tanker; 28,000 dwt and 38,000 dwt product carriers (loaded); steam diesel; single screw-50K; twin screw-56K; variable pitch propeller; triple screw-52K; LNG-125,000 m^3

TARGET SHIPS

RADAR: 3 targets, landmass, 2°

VISUAL: None (NAVAIDS only)

SOFTWARE
Variable water depth, shallow water effects, wind, current, tug forces

CONTROL
Malfunctions (propulsion, steering, compass, Decca, Doppler), data record

NAME: Port Revel

LOCATION: (SOGREAH) Grenoble

DESIGNER/MANUFACTURER: Originally Exxon, now operated by SOGREAH

COMPUTER TYPE: None

OBJECTIVE: Training; some research

OPERATIONAL STATUS: 1967

BRIDGE SIZE: None

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
1/25 scale models

FIELD OF VIEW
Total

SIZE OF GAMING AREA(S)
8 acre lake, 3 mi x 2 mi

VISUAL DETAILS
Total-actual visual scenes

SIMULATION CAPABILITIES

OWN SHIP
8 scaled vessels, including 500,000 dwt to 20,000 dwt tankers, and 120,000 cum LNG

TARGET SHIPS

RADAR: None, no radar capability

VISUAL: Up to 7 ships simultaneously (usually 3-4), each with an independent operator

SOFTWARE
RPM, rudder, vessel position, heading, speed, wind speed

CONTROL
No control station, operators ride on models

NAME:	Netherlands Ship Model Basin Simulator
LOCATION:	P.O. Box 28, Wageningen, Holland
DESIGNER/MANUFACTURER:	TNO-TWECO-Delft Electronic Assoc. hybrid computer & recording
COMPUTER TYPE:	Hybrid computer EAI-690 PDP 11/45, general purpose 16 bit 96K core
OBJECTIVE:	Research and Training
OPERATIONAL STATUS:	November 1969; 1976 interactive (i.e., dual simulator using a common computer)
BRIDGE SIZE:	4m depth, 6m width (1st simulator with outside view) 6m depth, 10m width (2nd simulator without outside view)

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Shadow graph point light source, 500w xenon (3-D cutout), color filters, 2 projectors, cylindrical screen, 20.4m diameter, 9.1m height

FIELD OF VIEW
360° capability; +25° -15° vertical; funnel blocks rear view by several degrees

SIZE OF GAMING AREA(S)
Any range on request

VISUAL DETAILS
Color, black/white, day, fog, landmarks, lead lines, buildings, resolution: 2 arc minutes

SIMULATION CAPABILITIES

OWN SHIP
80,000 dwt, 250,000 dwt, 165,000 dwt tankers (loaded); 250,000 dwt tanker (½ loaded); 42,000 m^3 dwt, 62,500 dwt containership; 125 m^3 LNG carrier

TARGET SHIPS

RADAR: Analog Marine Radar Simulator, Digital Radar Simulator

VISUAL: None

SOFTWARE
Winds, currents, tug forces, bank effects, depth effects, passing ship forces steam turbine, diesel

CONTROL
Malfunctions data recording, all controls, instruments and position systems (individually), manually from control panel or automatically by computer program

NAME: SR151 Ship Maneuvering Simulator

LOCATION: University of OSAKA, Department of Naval Architecture
Osaka, Japan

DESIGNER/MANUFACTURER: Hitachi Electronics Co. LTD.

COMPUTER TYPE: ALS-X Hybrid Analog

OBJECTIVE: Research

OPERATIONAL STATUS: 1975

BRIDGE SIZE: 3m depth, 5m width

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
TV camera and ship model, cylindrical projection of distant objects screen: 4m radius, 2m height, color transparency for background projection

FIELD OF VIEW
240° horizontal, +10° -15° vertical

SIZE OF GAMING AREA(S)
1-10nm in radius

VISUAL DETAILS
Color, black/white, resolution: 2 arc minutes for TV projection

SIMULATION CAPABILITIES

OWN SHIP

TARGET SHIPS

RADAR: 1 target, stationary ships/navigational buoys (3)

VISUAL: 1 ship

SOFTWARE
Depth effects, bank effects: double banks (straight canal only)

CONTROL

NAME:	Navigation Simulator System
LOCATION:	Tokyo University of Mercantile Marine
DESIGNER/MANUFACTURER:	---
COMPUTER TYPE:	PDP 11 Micro-Computer 36 bit 48K core
OBJECTIVE:	Research and Training
OPERATIONAL STATUS:	October 1976
BRIDGE SIZE:	5.2m width, 2.8m depth

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Graphic generator and mixer, 2 silhouette projectors, cylindrical screen (4m radius, 1.8m height)

FIELD OF VIEW
240° horizontal, +15° -12° vertical

SIZE OF GAMING AREA(S)
Harbor representation

VISUAL DETAILS
Color

SIMULATION CAPABILITIES

OWN SHIP
Various size 5-530M in length

TARGET SHIPS

RADAR: N.A.

VISUAL: 2

SOFTWARE
Wind, sea state, currents, tug forces, swell, cargo loading effects

CONTROL
Record/playback/freeze, vary time scale, target ship control, various malfunctions

NAME: Steering Simulator

LOCATION: University of Hiroshima, Hiroshima, Japan

DESIGNER/MANUFACTURER: Ship Motion Laboratory, Hiroshima University

COMPUTER TYPE: Analog

OBJECTIVE: Research for Manual Steering

OPERATIONAL STATUS: 1971

BRIDGE SIZE: 2m depth, 2m width

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Color projector (or point light projector), flat screen (2m width, 1m height)

FIELD OF VIEW
90° horizontal, $\pm 30^{\circ}$ vertical

SIZE OF GAMING AREA(S)
$\pm 100^{\circ}$ of heading angle

VISUAL DETAILS
Color

SIMULATION CAPABILITIES

OWN SHIP

TARGET SHIPS
RADAR: None
VISUAL: 1

SOFTWARE

CONTROL

NAME: *LMT Simulator and Electronic Systems Division

LOCATION: Trappes, France

DESIGNER/MANUFACTURER: LMT, Division Simulateurset Systems Electronique

COMPUTER TYPE: ---

OBJECTIVE: Training

OPERATIONAL STATUS: Not operational

BRIDGE SIZE: ---

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
TV camera and models inset with computer-generated images

FIELD OF VIEW
360^{o}

SIZE OF GAMING AREA(S)
Course 20 nm in length; channel or coastal

VISUAL DETAILS
Day/night, color, projected to ∞ , resolution: 6m at 5nm, true perspective with curvature

SIMULATION CAPABILITIES

OWN SHIP
Various sizes, 500 through 300,000; engines: diesel, turbine-electric, diesel-electric, gas or steam turbine

TARGET SHIPS

RADAR: ---

VISUAL: 5

SOFTWARE
Sea bottom tidal streams, wind, waves, deep or shallow water, rain, fog

CONTROL
---

*Not currently in operation

NAME: Institute for Perception - TNO

LOCATION: 5 Kampweg, Soesterberg Holland

DESIGNER/MANUFACTURER: Institute for Mechanical Construction - TNO

COMPUTER TYPE: PDP 11/15

OBJECTIVE: Research

OPERATIONAL STATUS: 1976

BRIDGE SIZE: 7m width, 5m depth

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Model board, point light source, 3 TV projectors, flat screen with endoscope and prismatic mirrors

FIELD OF VIEW
120° horizontal with possible 360° (3-9 sides prismatic mirror) +10-20 vertical

SIZE OF GAMING AREA(S)
Horizontal 17m x 23m; Oude-Maas, Hartel Canal, 2-8 nm x 3.4 nm, North Sea Den Hoelder Harbor

VISUAL DETAILS
Black/white, day, landmass, buoys/NAVAIDS, fog, resolution: 8-10 arc minutes

SIMULATION CAPABILITIES

OWN SHIP
Tug and tow

TARGET SHIPS
RADAR: Digital Radar Signal Generator PDP 11/34, Flying Spot Scanner-CAS
VISUAL: 1 on preset course

SOFTWARE:
Wind, currents, water depth, bank effects, passing effects, tug forces

CONTROL
Introduce malfunctions, data record

NAME:	Swedish State Shipbuilding Experimental Tank Simulator (SSPA)
LOCATION:	Gothenburg 24 Sweden
DESIGNER/MANUFACTURER:	Engineering Staff Chalmers University Gothenburg, Sweden
COMPUTER TYPE:	EAI hybrid computer 16K core; 2 large analog computers; 1 digital computer; 2 small analog computers
OBJECTIVE:	Research and Training
OPERATIONAL STATUS:	1967
BRIDGE SIZE:	5m x 5m^2

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Closed circuit TV scanning electrically generated; 7 TV screens located in wheelhouse windows (back projection); own ship projected separately

FIELD OF VIEW
120^o horizontal, 15^o vertical

SIZE OF GAMING AREA(S)
Europort - Rotterdam, Brofjorden - Sweden; Forshemmen - Goteborg

VISUAL DETAILS
Simple topographical features; navigational aids; day, black/white; CRT for "Birds Eye" view for berthing; ships bow, resolution: 25x25 arc minutes per picture element

SIMULATION CAPABILITIES

OWN SHIP
350,000 dwt single-screw steam turbine tanker; 280,000 dwt single-screw steam turbine/motor tanker, 265,000 dwt twin-screw motor bulk carrier; 135,000 single-screw motor tanker; 30,000 dwt twin-screw containership; 15,000 dwt single-screw RO-RO ship; 8,000 grt twin-screw ferry

TARGET SHIPS

RADAR: 1 (landmass, NAVAIDS)

VISUAL: "Simple" shapes for moving ship

SOFTWARE
Winds, currents, tug forces (10 tugs), up to 6 operating separately at the same time, variable water depths, bank effects

CONTROL
Malfunctions (propulsion, steering, engine alarms), data recording

NAME: Bremen Nautical Academy Shiphandling Simulator

LOCATION: German Academy of Nautical Sciences; Bremen, W. Germany
28 Bremen, Hunafeldstrasse 1-5, W. Germany

DESIGNER/MANUFACTURER: VFW Fokker and Hochschule fur Nautik (HFN)

COMPUTER TYPE: Digital computer, Modcomp 11/25, 16 bit 48K core memory,

OBJECTIVE: Training and Education

OPERATIONAL STATUS: March 1975

BRIDGE SIZE: 5m width, 4m depth

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Still transparencies (slides) with landmass projector, total of 2 projectors; additional projectors for own ship, sea, sky. Also a projector for each NAV-AID, flat screen (2.5m x 6m)

FIELD OF VIEW
120° horizontal, -20° +20° vertical

SIZE OF GAMING AREA(S)
Open sea and night with 6 navigation marks; unlimited, coastal approach, 9 x 12nm, harbor approach, 3 x 4nm light spot

VISUAL DETAILS
Day/night, color, sea state, clouds, landmarks, lead lines, NAVAIDS, fog, resolution: 3 arc minutes, bow waves

SIMULATION CAPABILITIES

OWN SHIP
221,000 dwt ton tanker, containership 66,000 dwt ton, cargo ship 17,000 disp. single/twin screw, steam, diesel

TARGET SHIPS

RADAR: 6 targets

VISUAL: None

SOFTWARE:
Winds, currents, water depth, anchoring

CONTROL
Data recording, malfunctions (gyro, propulsion, steering), wind shifts, current shifts, freeze capability

NAME:	Marine Safety International, LaGuardia Airport
LOCATION:	Flushing, New York (M.S.I.)
DESIGNER/MANUFACTURER:	Sperry Systems Management, Great Neck, N.Y.
COMPUTER TYPE:	Digital Varian 620/L-100 16 bit 32K core
OBJECTIVE:	Training
OPERATIONAL STATUS:	November 1976
BRIDGE SIZE:	4.3m depth, 6.1m width

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE

Model Board, optical probe, TV projection, 3 Eidophor projectors, circular screen, 6 mirrors, 7.6m radius, 18.3m length, 4.3m height

FIELD OF VIEW

140° horizontal, +10° -14° vertical

SIZE OF GAMING AREA(S)

Harbor approach to: Ras at Tannurah, Saudi Arabia; Ju'aymah; Savannah River; Milford Haven, Wales; Lower Chesapeake Bay; Elba Island, Georgia; Valdez/ Prince William Sound, Alaska

VISUAL DETAILS

Black/white, day/night, fog, buoys and NAVAIDS, clouds, own ship, bow, range lights 1/2 acc., resolution: 10 arc minutes per 2,000 ft.

SIMULATION CAPABILITIES

OWN SHIP

250,000 dwt tanker (loaded); 30,000 dwt tanker (loaded); 125m^3 LNG vessel

TARGET SHIPS

RADAR: SY2058 Coastline Generator Flying Spot Scanner

VISUAL: up to 12 tugs berthed and/or anchored; other vessels available on the model board

SOFTWARE

Winds, currents, variable water depths, tug forces

CONTROL

Malfunctions (propulsion, steering, bow thruster, stern thruster, electric power), record/playback, freeze, up to 64 light patterns, instant replay

NAME: Southampton School of Navigation

LOCATION: Warsash, Southampton SO3 6ZL

DESIGNER/MANUFACTURER: Decca Radar Ltd. Lyon Road, Walton-on-Thames Surrey England

COMPUTER TYPE: Digital Konsberg KS500

OBJECTIVE: Training, some research

OPERATIONAL STATUS: Operational, 1976, commercial training, February 1976

BRIDGE SIZE: 4.0m x 4.0m

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Spot projection, back projection, flat screen, 16 spot projectors, computer controlled, lights only

FIELD OF VIEW
100° horizontal 22° vertical above horizon, 27° vertical beyond horizon

SIZE OF GAMING AREA(S)
No restriction; lights for: (1) Dover Strait, (2) E. Solent, (3) W. Solent, (4) Southampton, (5) Avonmouth, (6) Malacca Straits, (7) Sugepass Strait, (8) Persian Gulf, 360° maneuvering capability

VISUAL DETAIL
Color, night only, maximum 4 ships, sea state, own ships bow and bow wave, fog, resolution: 0.5 arc minutes

SIMULATION CAPABILITIES

OWN SHIP
253,000 dwt, 220,000 dwt, 108,000 dwt tankers; 40,000 dwt container, 18,000 cargo, 125m^3 LNG

TARGET SHIPS

RADAR: 14 maximum, correlate with visual scene

VISUAL: 4 maximum, up to 16 lights at one time for NAVAIDS and ships combined

SOFTWARE
Wind, currents, shallow water effect 3-5' under keel, clearance for VLCC, tug forces (3), diesel/steam turbine vibration and noise

CONTROL
Freeze/record/playback, target ships (lights) may be pre-programmed or operator controlled. Malfunctions include propulsion, steering, radar, NAVAID, indicator

NAME:	Ishikawajima Harima Heavy Industries Co. Ltd.
LOCATION:	Tanashi Plant, Tokyo
DESIGNER/MANUFACTURER:	IHI and NAC (optics)
COMPUTER TYPE:	Y-316 Yamatake, 16 bit 24K core memory
OBJECTIVE:	Training; ship development and human factors analysis
OPERATIONAL STATUS:	1975
BRIDGE SIZE:	4.1m depth, 8.4m width

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE

Rear slide projector system, independent film projectors for background, own ship's wake, curved screen 9.8m x 3.4m. Note: other ships show change in attitude and angle by use of "Dual Image Processing", optical mechanism employed to achieve lateral and vertical translation and zooming

FIELD OF VEIW

100^{o} horizontal, $+30^{o}$ -30^{o} vertical

SIZE OF GAMING AREA(S)

0.3 - 8 nm ocean/coastal waters and harbor

VISUAL DETAIL

Color, waves, bow waves - film, day/night, fog, color, clouds, own ship, sea state, Furederk Islands, buoys, NAVAIDS

SIMULATION CAPABILITIES

OWN SHIP

200,000 dwt tanker, VLCC, ULCC, Containership, (up to 12 types) - 10-40 kts.

TARGET SHIPS

RADAR: up to 10

VISUAL: up to 5 VLCC, ULCC, (0-40 kts.)

SOFTWARE

Winds, currents, waves, cargo loading effects

CONTROL

Record/playback, pen recorder, target ship, control, introduce malfunctions, may display X,Y plotter, control ship aspect

NAME: Navigation Lights Simulator

LOCATION: German Academy of Nautical Sciences; Bremen, W. Germany
28 Bremen, Hunafeldstrasse 1-5, W. Germany

DESIGNER/MANUFACTURER: VFW Fokker and Hochschule fur Nautik (HFN)

COMPUTER TYPE: Modcomp 11/25, 16 bit, 48K core

OBJECTIVE: Training

OPERATIONAL STATUS: March 1978

BRIDGE SIZE: 2m x 1.5m

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Spotlight projectors: Navigation lights of target ships, slide projection: foredeck own ship, cylindrical screen 6m radius

FIELD OF VIEW
315^{o} horizontal, $+12^{o}$ -16^{o} vertical

SIZE OF GAMING AREA(S)
11 x 11 nm

VISUAL DETAILS
Color, 12 (16 possible) light spots, fog, horizon projection, resolution: 1 arc minute

SIMULATION CAPABILITIES

OWN SHIP
17,000 dwt freighter, 220,000 dwt VLCC

TARGET SHIPS

RADAR: None

VISUAL: 12 (16 possible) light spots

SOFTWARE
Variable water depths

CONTROL
Malfunctions (propulsion, steering, "radar-information", navigation lights)

EXAMPLES OF RADAR SIMULATORS

NAME:	Solartron Schlumberger
LOCATION:	Royal Netherlands Naval College, Den Hoelder, Netherlands
DESIGNER/MANUFACTURER:	SY2080 simulator made up of 4 basic units: (1) computer cabinet, (2) coastline generator, (3) instructor's control unit, (4) own ship control unit
COMPUTER TYPE:	Shipborne radar trainer - SY2081, coastline generator SY2072, X,Y plotter
OBJECTIVE:	Training
OPERATIONAL STATUS:	1971
BRIDGE SIZE:	4.60m width

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
Photographic plates, radar presentation only, light dot projection

FIELD OF VIEW
130°

SIZE OF GAMING AREA(S)
Photographic plates: 60 x 60 mi or 30 x 30 miles (where higher resolution is required for in-shore pilotage; own ship is in the center of an 80 mile square area

VISUAL DETAILS
Coastline, piers, buoys, hills, topographical features, white/grey, black

SIMULATION CAPABILITIES

OWN SHIP
Maximum of 4 own ships

TARGET SHIPS

RADAR: 8

VISUAL: None

SOFTWARE
Tidal stream, variable own ship characteristics, sea clutter, target range of detection, radar blanking sectors

CONTROL
Freeze/run, malfunctions (propulsion, steering gear, electric power)

NAME: Marconi Radar Systems Limited

LOCATION: United States Navy, Orlando, Florida

DESIGNER/MANUFACTURER: ---

COMPUTER TYPE: Computer generated imagery, TEPIGEN television picture generator

OBJECTIVE: Radar training

OPERATIONAL STATUS: 1972

BRIDGE SIZE: ---

VISUAL PRESENTATION

PROJECTION TECHNIQUE/IMAGE SOURCE
TV picture synthesized wholly from a computer without use of TV camera, videotape, or film

FIELD OF VIEW

SIZE OF GAMING AREA(S)
30 square miles, coastline, islands, sea, other shipping, 6 exercise areas: (1) Humber Estuary, (2) Dover Strait, (3) Donegal Bay, (4) Pentland Firth, (5) Godthaab, (6) Hekkingen

VISUAL DETAILS
Varying visibility, day/night

SIMULATION CAPABILITIES

OWN SHIP
3 own ships

TARGET SHIPS

RADAR: 8

VISUAL: None

SOFTWARE
Echo intensity and spot size increase with decreasing range from own ship, controlled sea clutter out to a range of 3 miles, current, target aspect visible on large target at short range, buoys of different sizes and means available, combination of analog landmass signals and local coast, tide and current effects variable over 360° and from 10 to 10 kts.

CONTROL
(1) relative motion radar displays, (2) ARL plotter, (3) record and playback facilities, (4) alphanumeric control display

TABLE E-1-1. COMPARISON OF SIMULATOR VISUAL PRESENTATION FEATURES

FACILITY	PROJECTION TECHNIQUE/IMAGE SOURCE														HORIZONTAL FIELD OF VIEW				VISUAL DETAIL							
	TV PROJECTOR	SLIDE PROJECTOR	CGI	SHADOWGRAPH	PRISMATIC MIRRORS	PROBE	GRAPHIC GENERATOR/ MIXER	SPOT PROJECTION	POINT LIGHT SOURCE	MODEL	PHOTOGRAPHIC PLATE	CURVED SCREEN	FLAT SCREEN	CRT WINDOWS	LESS THAN 100°	100° – 160°	161° – 240°	241° – 360°	COLOR	BLACK & WHITE	FOG	DAY	NIGHT	NAVAIDS	TOPOGRAPHICAL FEATURES	MOVING WATER (BOW WAVE, WAKE)
CAORF – NEW YORK	●		●									●					●		●	●	●	●	●	●	●	
TNO–M – DELFT				●					●				●			●			●	●	●	●	●	●	●	●
MSI – NEW YORK	●				●	●				●		●				●				●	●	●	●	●		●
SOUTHAMPTON SCHOOL OF NAV WARSASH								● (LIGHTS ONLY)					● (LIGHTS ONLY)			●			●	●	●		●	●		●
IHI – TOKYO		●										●				●			●		●	●	●	●	●	●
TNO–P – SOESTERBERG	●				●				●	●			●			●				●	●	●		●	●	
SSPA – GOTHENBURG	●		●											●		●				●		●		●	●	
NAUTICAL ACADEMY SHIPHANDLING – BREMEN		●											●			●			●		●	●	●	●	●	●
NETHERLANDS SHIP MODEL BASIN – WAGENINGEN				●					●			●						●	●	●	●	●		●	●	
SHIP SIM, OSAKA	●								●			●					●		●	●						
NAV SIM, TOKYO	●						●					●					●		●							
LMT DIV – TRAPPES	●		●							●		●						●	●			●	●			
UNIV. OF HIROSHIMA									●				●		●				●							
BREMEN – NAVIGATION LIGHTS SIMULATOR		●							(LIGHTS ONLY)			●						●	●		●		●			

TABLE E-1-2. COMPARISON OF SIMULATOR CAPABILITIES-TARGETS, OWN SHIP, TAT

FACILITY	TARGET CAPABILITY VISUAL	TARGET CAPABILITY RADAR	COLLISION AVOIDANCE	OWN SHIP TYPES	OWN SHIP SPEED	TRAINING ASSISTANCE TECHNOLOGY RECORD	PLAYBACK	FREEZE	VARY TIME SCALE	SPECIAL MANEUVERS DOCKING	MOORING	ANCHORING	BOW THRUSTER
CAORF	UP TO 6 SHIPS AT ONE TIME UP TO 12 DIFFERENT	UP TO 40 LANDMASS	•	VARIOUS TANKER LNG CONTAINER UP TO 15	0–30 KTS	•	•	•					•
TNO–M	NAVAIDS ONLY	UP TO 3 LANDMASS		UP TO 8 ULCC, VLCC, LNG, CARGO, CONTAINERSHIP	0–17 KTS	•					•	•	•
MSI	STATIONARY	NUMBER NOT AVAILABLE		3		•	•	•		•			•
SHIP & MARINE REQ. BD DECCA	UP TO 16 LIGHTS (SHIPS & NAVAIDS)	UP TO 14	•	ULCC, CARGO LNG CONTAINERSHIP		•	•	•			•	•	
IHI	SHIPS–UP TO 5 VLCC, ULCC OTHER TYPES (0-40 KTS)	UP TO 10	•	UP TO 12 ULCC, CONT. ETC	–10 TO +40 KTS	•	•			CRT ONLY			
TNO–P	1 SET COURSE	NUMBER NOT AVAILABLE	•	TUG & TOW (1)		•							•
SSPA	"SIMPLE" SHAPES	1 LANDMASS		7		•				CRT ONLY			•
BREMEN VFW FOKKER	NONE	UP TO 6		UP TO 3 CONTAINERSHIP TANKER, FREIGHTER	0 TO 27 KTS	•		•				•	•
NETHERLANDS SHIP MODEL BASIN	NONE	NUMBER NOT AVAILABLE		5		•							•
SHIP SIM, OSAKA	1	1											
NAV SIM, TOKYO	2	NONE	•	5 TO 350M	0–99.9 KTS	•	•	•	•	•			
LMT DIV.	5			VARIOUS UP TO 300K									
UNIV. OF HIROSHIMA	1	NONE		1		•							
BREMEN–NAVIATION LIGHTS SIM.	LIGHTS ONLY 12 (16 POSSIBLE)	NONE		VLCC FREIGHTER	0–24.5 KTS								

TABLE E-1-3. COMPARISON OF SIMULATOR CAPABILITIES- SCENARIO, SOFTWARE, MALFUNCTIONS, AUDIO

FACILITY	BRIDGE SIZE	EXERCISE AREA TYPE AND SIZE			SOFTWARE										MALFUNCTIONS					AUDIO				
		OCEAN	COASTAL	HARBOR	WIND	CURRENT	DEPTH	SHALLOW WATER AND/OR BANK EFFECTS	PASSING SHIP	TUG FORCES	SEA STATE	SWELL	CARGO LOADING EFFECTS		STEERING	PROPULSION	ELECTRIC POWER	OTHER		OWN SHIP HORN	OTHER SHIP HORN	ENGINE & PROPELLER	COMMUNICATIONS	NAVAIDS
CAORF	4.3m x 6.1m	50 x 100 (NM)		*VALDEZ 50X50(NM) SANTA BARBARA CHANNEL 60X120(NM) ETC	●	●	●	●	●	●			●		●	●	●			●	●		●	
TNO-M	4.5m x 3.5m	NO RESTRICTIONS	18 NM DIA.	5 NM DIA.	●	●	●	●		●					●	●	●	●						
MSI	4.3m x 6.1m	5x10(NM)	5x10(NM)	* 5x10(NM) RAS AT TANNURAH MILFORD HAVEN, ETC	●	●	●	●		●					●	●	●	●		●		●	●	●
SHIP & MARINE REQ BD DECCA	4.0m x 4.0m		DOVER STRAIT	SOUTHAMPTON MALACCA STRAITS, ETC	●	●	●	●		●	●				●	●		●			●	●		
IHI	4.1m x 8.4m	RADAR 24 NM 3 TO 8 NM	RADAR 24 NM 3 TO 8 NM	RADAR 24 NM 3 TO 8 NM	●	●					●		●		●	●		●		●				●
TNO–P	7m x 5m	17 x 23 (NM) 2.8 x 3.4 (NM)		HARTEL CANAL DEN HOELDER, ETC	●	●	●	●	●	●								●		●			●	
SSPA	5m x 5m^2			EUROPORT–ROTTERDAM GOTEBORG, ETC	●	●	●	●		●					●	●		●					●	
BREMEN VFW FOKKER	5m x 4m	UNLIMITED	9 x 12 NM	3 x 4 NM	●	●	●						●		●	●		●		●		●	●	
NETHERLAND SHIP MODEL BASIN	4.n x 6m 6m x 10m	ANY RANGE ON REQUEST			●	●	●	●	●	●								●						
SHIP SIM. OSAKA	3m x 5m	1 TO 10 NM					●	●																
NAV. SIM. TOKYO	5.2m x 2.8m				●	●					●	●	●					●		●				
LMT DIV.			COURSE 20 NM IN LENGTH		●	●	●	●			●													
UNIV. OF HIROSHIMA	2m x 2m																							
BREMEN–NAVIGATION LIGHTS SIM.	2m x 1.5m						●								●	●		●			●			

*ADDITIONAL HARBOR AREAS AVAILABLE

TABLE E-1-4. BRIDGE EQUIPMENT ON VARIOUS SIMULATORS

	CAORF	SSPA	SOUTHAMPTON NAVSCOL, WARSASH	NSMB	TOKYO MERCANTILE MARINE	IHI	BREMEN	MSI	UNIV. OF HIROSHIMA	SHIP SIM - OSAKA	TNO-P	TNO-M	BREMEN NAVIGATION LIGHTS SIMULATOR
STEERING STAND	●	●	●	●		●	●	●	●	●		●	
AUTO PILOT	●	●	●	●	●	●	●	●		●	●	●	
GYROCOMPASS	●	●	●	●	●	●	●		●				●
ENGINE TELEGRAPH	●	●	●	●	●	●	●	●		●	●	●	●
ENGINE REMOTE CONTROL	●	●	●	●		●						●	
VHF COMMUNICATION SYSTEM	●	●	●	●			●	●			●	●	●
INTERCOM SYSTEM	●	●	●	●			●	●			●	●	●
BOW THRUSTER	●	●		●			●	●			●	●	
STERN THRUSTER	●	●		●				●			●	●	
CLOCK	●		●										
RUDDER ANGLE INDICATOR	●	●	●	●	●	●	●						●
RATE OF CHANGE OF HEADING INDICATOR	●	●	●			●	●	●		●			●
RPM INDICATOR	●	●	●	●	●	●	●			●			●
SPEED LOG	●	●	●	●	●	●		●					●
ECHO SOUNDER	●	●		●			●					●	
REPEATER COMPASS	●	●		●		●				●			
RELATIVE WIND DIRECTION	●	●	●	●		●	●	●		●			
RELATIVE WIND SPEED	●	●	●	●		●	●	●		●			
DOPPLER SONAR DOCKING SYSTEM		●					●	●					
SHIP POSITION						●							
PATH PLOTTER	●		●			●							
LINEAR ACCELERATION INDICATOR		●											
CHART TABLE	●	●	●	●									
RADIO DIRECTION FINDER							●						
DECCA NAVIGATOR		●	●	●	●		●	●				●	
OMEGA					●								
LORAN	●				●		●						
RADAR	●	●	●	●	●	●	●	●		●	●	●	

EXHIBIT E-2

TRAINING SIMULATOR SUBSYSTEMS

EXHIBIT E-2

TRAINING SIMULATOR SUBSYSTEMS

As part of the training system design process, the composite of possible simulator systems currently available has been subdivided into twelve functional subsystems, thus providing a practical means of correlating specific functional objectives with specific hardware capabilities. The hardware capabilities comprising each subsystem were selected based on commonality of function and minimal crossover into other subsystems, so that technical changes within a subsystem would have minimal effect on costs and system downtime. The twelve functional subsystems are:

I. Visual Image Display
II. Image Generation
III. Radar/Collision Avoidance
IV. Bridge Equipment Configuration
V. Audio
VI. External Factors
VII. Own Ship Motion Base
VIII. Control Mode
IX. Facility Arrangement
X. Own Ship Characteristics and Dynamics
XI. Own Ship Malfunction
XII. Training Assistance Technology

I. VISUAL IMAGE DISPLAY

This subsystem is composed of components that permit, facilitate, or degrade the trainee's functional perception of the given visual conditions of a scenario. This subsystem addresses not only absolute parameters such as color, day/night, field of view, and contact motion, but also the degree to which certain parameters such as resolution, luminance, and contrast affect the overall effectiveness of the training device system.

II. IMAGE GENERATION

The image generation system consists of two parts: a projection system and a reflection or display system. The prime determinant of the image generation system is image storage. Images can be stored on slides, on film, as a model board, or be generated by computer. Each storage method imposes constraints on image projection and display. The projection system may thus range in complexity from a single point light source (bulb) to slide, film, or television projection; the screen used in the display system may vary correspondingly in material, size, configuration, and lighting method.

III. RADAR/COLLISION AVOIDANCE

This subsystem provides a low visibility navigation capability and an automatic collision avoidance plotting system. It allows flexibility in varying the visibility levels in the simulated visual scene for navigation and collision avoidance scenarios. Inclusion of automatic tracking and trial maneuver features in this subsystem allows for training in appreciation of relative motion.

IV. BRIDGE EQUIPMENT CONFIGURATION

This subsystem delineates the types of equipment which may be included in a ship's bridge. Any individual ship may include the equipment to a greater or lesser degree depending on the ship's age, route, and service.

V. AUDIO

This subsystem includes both natural external and internal ship sounds to provide a realistic bridge background and auditory cues for scenario conditions. It can be used either independently or in conjunction with cues from other subsystems such as visual ship casualties or own ship motion.

VI. EXTERNAL FACTORS

This subsystem may be utilized to provide cues for ship maneuvering and navigation scenarios. External factors represent forces which are generated outside the vessel and for which the mariner must make adjustments in ship maneuvers. For simulation purposes, external factors have been grouped as pertaining to visibility, set and drift, sea state, or tug action and reaction.

VII. OWN SHIP MOTION BASE

Although own ship's motion may be simulated visually, vestibular stimulation may also be required for scenario realism. Pitch, roll, and heave can be provided to create or reinforce certain scenario situations.

VIII. CONTROL MODE

This subsystem is primarily concerned with providing the capability to apply varied, complex, and coordinated training methods as dictated by the training situation and/or scenario content. The capabilities addressed in this subsystem must be inherent in the hardware. They are:

a. Normal-fast time
b. Problem start/restart
c. Problem freeze
d. Record (video, audio)
e. Playback
f. Exercise duration

IX. FACILITY ARRANGEMENT

This subsystem is primarily concerned with the interfaces of various ancillary facilities and their impact on the training process. These ancillary facilities are:

a. Wheelhouse
b. Instructor station
c. Observation/evaluation station
d. Classrooms
e. Computer facility
f. Ready room or orientation room
g. Maintenance shop
h. Office space

X. OWN SHIP CHARACTERISTICS AND DYNAMICS

This subsystem provides the programs to realistically model own ship including ship configuration and ship hydrodynamics as impacted by local conditions such as shallow water, wind, current, and bank effects. The advantage of this subsystem is that the initial investment required can be as limited or extensive as user resources permit. Likewise, the software base can be expanded within the capability of the associated hardware, within any specified time period.

XI. OWN SHIP MALFUNCTION

This subsystem permits advanced training in shipboard casualties. Malfunctions may be imposed with more sophistication than that provided by an instructor's ON-OFF control. Casualties have been grouped by function to include steering, propulsion, electric power, radar/CAS, and ship control indicators. The interaction of simultaneous casualties of various ship systems, utilized on a coordinated basis, can provide not only basic ship system training, but also flexible degrees of stress to permit trainee performance measurement.

XII. TRAINING ASSISTANCE TECHNOLOGY

Training assistance technology, although not a subsystem in the same sense as the other subsystems, constitutes a distinct function in that it allows the hardware components which comprise the other subsystems to be utilized fully. Training assistance technology is divided into data recording, data reduction, observation/monitoring, performance measurement, diagnostic feedback/demonstration, problem control, and a long term storage library.

EXHIBIT E-3

ALTERNATIVE CHARACTERISTIC CAPABILITIES AND LIMITATIONS

ALTERNATIVE CHARACTERISTIC CAPABILITIES AND LIMITATIONS

This exhibit delineates the capabilities and limitations of subsystem char teristic alternatives. The matrix format enables one to define clearly th ability of the various alternative characteristics to support the SFOs. S subsystems (e.g., bridge equipment configuration) provide alternatives whi may not be mutually exclusive. Coordinated use of several of the alternat could enhance the overall capability of the training device to complete th training objectives.

Characteristics for subsystem 12, Training Assistance Technology, were eva ated in accordance with the Note contained at the beginning of the subsyst section. By their nature, these characteristics are capable of interactiv relationships which can increase the overall effectiveness of the training simulator. These characteristics are evaluated by the benefits they provi individually, but combinations of these alternatives may qualitatively imp the training simulator in a variety of functional areas.

Exhibit E-3 should be utilized for preliminary evaluation of the training device characteristics on an absolute basis. Quantitative evaluations of characteristics to perform specific training objectives are contained in E hibit E-4.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS

I. SUBSYSTEM: Visual Image Display

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Color

1. CHARACTERISTIC'S SPECIFICATION: Black and white

CAPABILITIES	LIMITATIONS
a. Traffic ship aspect enhanced by use of silhouette.	a. Identification of specific contacts difficult due to lack of color cues.
b. Wave and cloud simulation possible.	b. Color coding of navaids cannot be used.
c. Depth perception minimally enhanced by shades of gray.	c. Lack of color shading degrades depth perception.
d. Multiplicity of traffic ship sizes and shapes can be utilized.	d. Identification of ship signal flags not possible.
e. White lighted traffic contacts and navaids can be utilized.	e. Exercise area representation may suffer from lack of realism.
f. Visual signaling by ship traffic possible.	f. Ship sidelights and special lights cannot be represented.
g. Environmental effects can be represented.	g. Lack of color may limit some scenarios and/or training objectives.
h. Duration coding of navaid lights can be utilized.	
i. Shape identification of navaids can be utilized.	

2. CHARACTERISTIC'S SPECIFICATION: Multicolor

CAPABILITIES	LIMITATIONS
a. Traffic ship aspect enhanced by use of silhouette.	a. Multiplicity of color might prove to be distracting if not utilized judiciously (i.e., flashing neon signs on shore).
b. Wave and cloud simulation possible.	b. System limitation may affect chromatic fidelity.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Color

2. CHARACTERISTIC'S SPECIFICATION: Multicolor

CAPABILITIES	LIMITATIONS
c. Multiplicity of traffic ship sizes and shapes can be utilized.	
d. White lighted traffic contacts and navaids can be utilized.	
e. Visual signaling by ship traffic possible.	
f. Environmental effects can be represented.	
g. Duration coding of navaid lights can be utilized.	
h. Shape identification of navaids can be utilized.	
i. Ship sidelight display enhances representation of ship aspect.	
j. Special ship lights can be represented (i.e., breakdown, minesweeping, dredging, etc.)	
k. Depth perception enhanced by use of color shading.	
l. Multiplicity of colors can provide variety in traffic ship representation.	
m. Identification of navaids enhanced due to addition of color cues.	
n. Realism maximized for exercise area by use of color.	
o. Use of color maximizes flexibility, complexity and variety of scenarios.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Color

2. CHARACTERISTIC'S SPECIFICATION: Multicolor

CAPABILITIES	LIMITATIONS
p. Traffic ship signal flags can be color coded.	

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Day/night

1. CHARACTERISTIC'S SPECIFICATION: Night only

CAPABILITIES	LIMITATIONS
a. Lighted ship traffic can be utilized.	a. Visual scene limited to lighted objects only.
b. Visual signaling by ship contacts possible.	b. Perception of relative depth between objects is difficult.
c. Visual tracking of lighted ship contacts possible.	c. No surface wave/cloud simulation possible.
d. Traffic ship aspect can be visualized by use of sidelights and masthead lights.	d. No visual cues for man overboard unless a light is used to represent man and/or lifeboat.
e. Special ship situations can be represented (e.g., breakdown, minesweeping or dredging) with special contact ship lights.	e. Scenarios limited by lack of certain types of visual cues.
f. Environmental effects (i.e., rain, fog, snow) can be represented.	f. Representation of own ship bow wave and wake not available.
g. Imposes additional level of difficulty in shiphandling and navigation scenarios.	g. Unlighted navigation aids cannot be utilized.
h. Restricted and harbor waters navigation can be accomplished using lighted navaids.	h. Multiplicity of lights may inhibit identification of navaids.
i. Duration and color coding of navaid lights can be utilized for identification.	i. Flexibility of lengthy scenarios limited by not having visual daylight scene.
j. Judicious use of lighted objects can provide flexibility in both exercise area and scenarios.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Day/night

2. CHARACTERISTIC'S SPECIFICATION: Day only

CAPABILITIES	LIMITATIONS
a. Visual signaling by ship contacts possible.	a. Does not provide additional level of difficulty imposed by night operation scenarios.
b. Visual tracking of lighted ship contacts possible.	
c. Environmental effects (i.e., rain, fog, snow) can be represented.	
d. Visual scene can present unlighted objects.	
e. Depth perception enhanced by representation of relative size.	
f. Wave/cloud simulations possible.	
g. Visual cues can be presented for man overboard drills.	
h. Traffic ship aspect enhanced by use of silhouette.	
i. Own ship bow wave and wake representation possible.	
j. Traffic ship wake (cue to speed) representation possible.	
k. Multiplicity of traffic ship types (i.e., shape, size) can be utilized.	
l. Flexibility and variety available in selection of type of exercise areas.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Day/night

2. CHARACTERISTIC'S SPECIFICATION: Day only

CAPABILITIES	LIMITATIONS
m. Navaid detection and identification training can be maximized.	
n. Differentiation between unlighted navaids and ship traffic is maximized.	
o. Shape and color identification of navaids can be added to light characteristic coding.	
p. Variations in brightness and contrast can be utilized to represent twilight for scenario flexibility.	

3. CHARACTERISTIC'S SPECIFICATION: Day/night

a. Same as I.B.1 and I.B.2 above.	
b. Added flexibility of translation from day to night during long scenarios.	
c. Increased variety, complexity, and flexibility of scenario and exercise areas can be utilized.	

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Horizontal Field of View

1. CHARACTERISTIC'S SPECIFICATION: $\pm 60^{\circ}$ from bow

a. Visual representation of all types of exercise areas is possible.	a. Size and scale of exercise area limited visually to small segment ahead of ship.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Horizontal Field of View

1. CHARACTERISTIC'S SPECIFICATION: $\pm 60^{0}$ from bow

CAPABILITIES	LIMITATIONS
b. Rules-of-the-Road crossing and own ship overtaking situations can be represented visually.	b. Visual representations in scenarios limited by forward viewing only.
c. Ship maneuvers unlimited visually in the forward direction.	c. Edge matching problems due to multiple projectors may occur.
	d. Man overboard drill cannot be completed by use of visual cues only.
	e. Numbers of contacts (including landmass) limited by exercise area scale and configuration.
	f. Visual field of $\pm 60^{0}$ limits ship course change options.
	g. Lack of visual cues astern limits navigation scenarios.

2. CHARACTERISTIC'S SPECIFICATION: $\pm 90^{0}$ from bow

CAPABILITIES	LIMITATIONS
a. Visual representation of all types of exercise areas is possible.	a. Visual representation of exercise area limited to forward of own ship's beam.
b. Rules-of-the-Road crossing and own ship overtaking situations can be represented visually.	b. Visual representations of scenarios limited by forward viewing only.
c. Ship maneuvers unlimited visually in the forward direction.	c. Edge matching problems may occur.
d. Visual representation of scenarios can be expanded for complexity and flexibility over the 60^{0} F.O.V.	d. Man overboard drill cannot be done completely by visual cues.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Horizontal Field of View

2. CHARACTERISTIC'S SPECIFICATIONS: $\pm 90^{0}$ from bow

CAPABILITIES	LIMITATIONS
	e. Numbers of contacts (including landmass) limited by exercise area scale and configuration.
	f. Objects abaft the beam not visible.
	g. Lack of visual cues astern limits navigation scenarios.

3. CHARACTERISTIC'S SPECIFICATIONS: $\pm 120^{0}$ from bow

CAPABILITIES	LIMITATIONS
a. Visual representation of all types of exercise areas is possible.	a. Man overboard drill cannot be done completely with visual cues.
b. Rules-of-the-Road crossing and own ship overtaking can be represented visually.	b. Numbers of contacts (including landmass) limited by exercise area scale and configuration.
c. Ship maneuvers unlimited visually in the forward direction.	c. Objects directly astern are not visible.
d. Objects abaft the beam can be represented.	
e. Exercise area can be visually represented more realistically than under specification I.C.2.	
f. Visual representation of scenaric can be expanded for increased complexity and flexibility over $\pm 90^{0}$ F.O.V.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Horizontal field of view

4. CHARACTERISTIC'S SPECIFICATIONS: $\pm 360^0$ from bow

CAPABILITIES	LIMITATIONS
a. Exercise area visual flexibility maximized.	a. Edge matching problems are maximized by increased number of projectors required.
b. Scenarios unlimited by horizontal field of view.	
c. Objects astern can be viewed.	

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Vertical field of view

1. CHARACTERISTIC'S SPECIFICATIONS: 0^0 to $+10^0$

a. Scenarios at long and medium ranges are possible.	a. Objects close aboard not visible.
b. High structures (i.e., bridges) can be utilized in most scenarios.	b. Own ship bow representation very small or not available.
	c. Close range scenarios not realistic visually.
	d. Man overboard drill only possible by utilizing telephone information.
	e. No own ship bow wave representation available.

2. CHARACTERISTIC'S SPECIFICATIONS: $\pm 10^0$

a. Variable range scenarios possible.	a. Man overboard drill only possible by utilizing telephone information.
b. Navaids and channel transit exercises can be utilized at closer ranges than those at 0^0 to $+10^0$ (I.D.1).	b. Close range scenarios such as docking or mooring not possible visually.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Vertical Field of View

2. CHARACTERISTIC'S SPECIFICATIONS: $\pm 10^0$

CAPABILITIES	LIMITATIONS
c. Closer ranges would permit better resolution of targets and more realistic visual representation of exercise area than at 0^0 to $+10^0$ (I.D.1).	c. Objects close aboard amidships not visible.
d. Own ships bow would be available as reference point.	
e. Own ship bow wave and wake representation possible.	

3. CHARACTERISTIC'S SPECIFICATIONS: Greater than $\pm 10^0$

CAPABILITIES	LIMITATIONS
a. Same as a through e under I.D.2, above.	a. Minimum range abeam becomes a function of image generation system and display system capability.
b. Man overboard exercise may be executed visually.	
c. Close range scenarios possible.	
d. Objects close aboard may be visible.	

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Own ship motion

1. CHARACTERISTIC'S SPECIFICATIONS: One axis (X)

CAPABILITIES	LIMITATIONS
a. Straight course scenarios possible.	a. Shiphandling skills cannot be visually represented or evaluated.
b. Limited visual navigation plotting possible.	b. Very limited number of visual scenarios available for training purposes.
c. Ship speed can be visually represented by bow wave and wake.	c. Restricted waters and harbor areas cannot be utilized to best advantage.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS

I. SUBSYSTEM: Visual Image Display

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Own ship motion

1. CHARACTERISTIC'S SPECIFICATIONS: One axis (X)

CAPABILITIES	LIMITATIONS
d. Limited Rules-of-the-Road training can be accomplished up to point of own ship maneuver.	d. Certain ship characteristics (i.e., heel, roll, pitch) cannot be represented.
	e. Lack of realistic ship motion results in lack of realism for trainees.
	f. Little opportunity for exercise control (i.e., canned programs).
	g. Changes to own ship motion limited to speed changes.

2. CHARACTERISTIC'S SPECIFICATIONS: Two axes and rotation (X,Y,λ)

CAPABILITIES	LIMITATIONS
a. Ship speed can be visually represented by bow wave and wake.	a. Certain ship characteristics (i.e., heel, roll, pitch) cannot be represented.
b. Shiphandling skills can be evaluated.	b. Lack of realistic ship motion results in lack of realism for trainees.
c. Full range of difficulty of ship maneuver scenarios is possible.	c. Length of scenarios is governed by size of exercise area in relation to magnitude of course and speed changes of own ship.
d. Own ship characteristics can be represented more fully.	
e. Change in ships head in relation to surroundings adds realism to scenarios.	
f. Moderate amount of instructor control of visual representation of ship motion is possible.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Own ship motion

3. CHARACTERISTIC'S SPECIFICATIONS: Three axes and rotation (X,Y,Z,λ)

CAPABILITIES	LIMITATIONS
a. Same as a through e under I.E.2, above.	a. Possibility exists that excessive motion may inhibit training objectives.
b. Maximum amount of instructor control of visual representation of ship motion is possible.	b. Degree of dynamics limited by facility capability.
c. Visual own ship motion cues add increased realism to ship handling and casualty control scenarios.	c. Visual own ship movement in three planes would not be required in large number of harbor area scenarios.

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact motion

1. CHARACTERISTIC'S SPECIFICATIONS: Stationary

CAPABILITIES	LIMITATIONS
a. Visual navaids and channel representations possible.	a. Underway ship contacts cannot be represented visually.
b. Visual navigation plotting possible.	b. Collision avoidance exercises with vessels not possible due to lack of visual relative motion.
c. Visual landmass representation possible.	c. Minimal visual control of exercise by instructor exists.
d. Own ship motion represented in relation to all other objects is true motion.	d. Training in plotting visual moving contacts is not possible.
e. Larger number of contacts can be represented than if mobile contacts were utilized.	
f. Environmental effects can be represented.	

2. CHARACTERISTIC'S SPECIFICATIONS: One axis (X)

CAPABILITIES	LIMITATIONS
a. Visual navaids and channel representations possible	a. Number of contacts may be constrained by physical target track interference.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact motion

2. CHARACTERISTIC'S SPECIFICATIONS: One axis (X)

CAPABILITIES	LIMITATIONS
b. Visual navigation plotting exercises possible.	b. Very little exercise control by instructor is possible in the visual subsystem.
c. Visual landmass representation possible.	c. Lack of realistic contact motion results in canned exercises.
d. Environmental effects (i.e., set and drift) can be represented.	d. Traffic ship aspect may be fixed.
e. Limited Rules-of-the-Road and collision avoidance scenarios possible visually.	
f. Ships underway can be represented visually.	
g. Contact speed can be controlled by instructor.	
h. Limited visual relative motion can be represented.	
i. Simple relative motion visual plotting exercises can be accommodated.	

3. CHARACTERISTIC'S SPECIFICATIONS: Two axes (X,Y)

a. Visual navaids and channel representations possible.	a. Number of contacts may be constrained by physical target track interference.
b. Visual navigation plotting exercises possible.	b. Traffic ship aspect may be fixed.
c. Visual landmass representation possible.	c. Full instructor control of contact not possible in visual subsystem.
d. Environmental effects (i.e., set and drift) can be represented.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact motion

3. CHARACTERISTIC'S SPECIFICATIONS: Two axes (X,Y)

CAPABILITIES	LIMITATIONS
e. Ships underway can be represented visually.	
f. Contact speed can be controlled visually by the instructor.	
g. Ship maneuver problem complexity can be upgraded over limited Rules-of-the-Road, and collision avoidance scenarios are possible visually.	
h. Contact numbers and types can be realistic to match scenario complexity.	
i. Relative motion has maximum flexibility.	

4. CHARACTERISTIC'S SPECIFICATIONS: Rotation (⅄)

CAPABILITIES	LIMITATIONS
a. Visual navaids and channel representations possible.	a. Contact aspect must be closely correlated with its course and bearing from own ship to avoid negative training.
b. Visual navigation plotting exercises possible.	
c. Visual landmass representation possible.	
d. Environmental effects (i.e., set and drift) can be represented.	
e. Contact numbers and types can be realistic to match scenario complexity.	
f. Contact aspect can give true visual representation of contact course.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact motion

5. CHARACTERISTIC'S SPECIFICATION: Rotation (2)

CAPABILITIES	LIMITATIONS
g. Full instructor control of contact possible.	

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact control

1. CHARACTERISTIC'S SPECIFICATION: Fixed track

CAPABILITIES	LIMITATIONS
a. Provides relative motion between contacts and own ship, and between contacts.	a. Scenarios limited by configuration and number of tracks. (Canned exercises).
b. Limited collision avoidance, Rules-of-the-Road and navigation scenarios possible.	b. Number of mobile contacts limited by configuration of tracks and size of physical installation.
c. Contact maneuverability can be obtained.	c. Instructor control of exercise limited to selection of contact track and contact speed.
d. Contact aspect is automatically represented.	d. Level of training limited by facility capability.
	e. Change in scenario contact movement during progress of exercise is not possible.
	f. Length of exercise constrained by physical layout of tracks.
	g. Repositioning of contacts at intermediate point is time consuming and may be inaccurate for specific points in time within an exercise.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact control

2. CHARACTERISTIC'S SPECIFICATION: Preprogrammed (cassette/tape)

CAPABILITIES

a. Provides relative motion between contacts and own ship, and between contacts.

b. Contact maneuverability can be obtained.

c. Contact aspect is automatically represented.

d. Scenarios more flexible visually than under fixed track (I.G.1).

e. Instructor contact control enhanced by scenario selection flexibility.

f. Different levels of training selectable by choice of scenario complexity.

g. Number of contacts expanded over fixed track (I.G.1).

h. Dynamic environmental effects can be introduced (i.e., set and drift).

i. Image projection methods are flexible (i.e., slide projector, TV projector).

j. Repositioning of units to match specific times in scenario is possible.

k. Length of exercise can be expanded beyond that of fixed track (I.G.1).

LIMITATIONS

a. Diversity of types and action of contacts limited to number of programs available.

b. Changes to scenario while exercise is in progress is not possible.

c. Direct instructor control is minimal.

d. Length of exercise constrained by program used.

e. Environmental effects are constrained by program used.

f. Repositioning of contacts to intermediate specific positions may be limited by necessity to initiate from problem start time.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact control

3. CHARACTERISTIC'S SPECIFICATION: Flexible control (Computer-generated image, instructor console)

CAPABILITIES	LIMITATIONS
a. Provides relative motion between contacts and own ship, and between contacts.	a. Number of moving contacts limited by size and configuration of exercise area and the number of fixed contacts generated visually.
b. Contact maneuverability can be obtained.	
c. Contact aspect is automatically represented.	
d. Different levels of training selectable by choice of scenario complexity.	
e. Dynamic environmental effects can be introduced (i.e., set and drift).	
f. Image projection methods are flexible (i.e., slide projector, TV projector).	
g. Maximum visual selection of scenario complexity, variety, and difficulty is possible.	
h. Maximum visual selection of types of exercise areas is available.	
i. Maximum contact selection and contact maneuver response is possible visually.	
j. Maximum instructor control over visual exercise parameter exists.	
k. Visual repositioning of contact is possible at any point in exercise.	
l. Visual changes to scenario while exercise is in progress are possible.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

H. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Resolution

1. CHARACTERISTIC'S SPECIFICATION: Less than 10 minutes of arc

CAPABILITIES	LIMITATIONS
a. Small objects can be represented.	a. Image generation and projection equipment must have capability to reflect this amount of detail.
b. Large objects can be represented at longer ranges with greater detail.	b. Contrast ratio is critical to obtain recognition.
c. Scenarios not limited by size of objects represented visually.	
d. Contact extended ranges can be utilized in scenarios.	
e. Identification and/or recognition of objects is enhanced by finite detail.	
f. Maximum number of types of contacts can be represented.	
g. Landmass can be represented in greater clarity.	

2. CHARACTERISTIC'S SPECIFICATION: 10 to 20 minutes of arc

CAPABILITIES	LIMITATIONS
a. Optimal visual resolution quality for TV projected image.	a. Identification and recognition of smaller objects not possible due to lack of visual detail.
b. Visual contrast/illumination requirement not as stringent as for arc of less than 10 minutes (I.H.1).	b. Restricted waters and harbor area day scenarios may be limited by lack of detail.
c. Long range scenarios possible using larger visual contacts.	c. Accuracy of navigation in harbor scenarios affected by size of elements representing ranges, buoys, etc.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

H. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Resolution

2. CHARACTERISTIC'S SPECIFICATION: 10 to 20 minutes of arc

CAPABILITIES	LIMITATIONS
d. Scenarios representing most operational situations can be fully represented visually.	
e. Optimal number of contacts may be represented.	

3. CHARACTERISTIC'S SPECIFICATION: Over 20 minutes of arc

CAPABILITIES	LIMITATIONS
a. Contrast/luminance values can be reduced without inhibiting recognition factor.	a. Identification and recognition of smaller objects not possible due to lack of visual detail.
	b. Restricted waters and harbor area day scenarios may be limited by lack of detail.
	c. Accuracy of navigation in harbor scenarios affected by size of elements representing ranges, buoys, etc.
	d. Scenarios may be limited by image size and lack of detail.
	e. Night scenarios may be degraded by cues of unrealistic light size.

I. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Luminance

1. CHARACTERISTIC'S SPECIFICATION: Less than 5 ft Lamberts

CAPABILITIES	LIMITATIONS
a. Open sea scenarios possible. Day and night.	a. Contrast ratios must be high for object detection and identification.
b. Variable low visibility scenarios possible.	b. Large images with high resolution must be used to facilitate detection and identification.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

I. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Luminance

1. CHARACTERISTIC'S SPECIFICATION: Less than 5 ft Lamberts

CAPABILITIES	LIMITATIONS
c. Twilight representation is possible.	c. Restricted waters and harbor area scenarios limited under day conditions.
	d. Simulator ambient lighting must be low.
	e. Trainee visual viewing angle limited to approximately 90°.
	f. Trainees must be night adapted prior to exercise commencement.

2. CHARACTERISTIC'S SPECIFICATION: 5 to 10 ft Lamberts

CAPABILITIES	LIMITATIONS
a. Day and night open sea scenarios possible.	a. Ambient lighting ratio should be approximately 2:1.
b. Variable low visibility scenarios possible.	b. Visual viewing angle somewhat limited.
c. Twilight representation is possible.	c. Individuals with vision problems may not be able to discriminate/identify objects.
d. Acceptable limits for most large screen projection (i.e., movie, TV projector).	
e. Small images can be recognized.	
f. Visual viewing angle can be increased over that necessary for luminance of less than 5 ft Lamberts.	
g. Day scenarios can be run at longer ranges with smaller contacts.	
h. Contrast/resolution values not as critical as for luminance less than 5 ft Lamberts (I.I.1).	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

I. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Luminance

3. CHARACTERISTIC'S SPECIFICATION: 10 to 20 ft Lamberts

CAPABILITIES	LIMITATIONS
a. Optimal for most exercise conditions.	a. Sub-normal vision may not be able to discriminate.
b. Adequate for normal vision discrimination of detail.	b. Installation and maintenance of required illumination equipment may be more costly than that imposed by luminance of 5-10 ft Lamberts (I.I.2).
c. Minimal contrast/resolution required.	
d. Wider selection in viewing angles possible.	

4. CHARACTERISTIC'S SPECIFICATION: Greater than 20 ft Lamberts

CAPABILITIES	LIMITATIONS
a. Adequate for subnormal vision discrimination of detail.	a. Glare factor may inhibit training process.

J. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contrast ratio

1. CHARACTERISTIC'S SPECIFICATION: Less than 25%

CAPABILITIES	LIMITATIONS
a. Scenarios at short and medium ranges possible (day).	a. Intensity/resolution factors must be maximized to permit discrimination/recognition.
b. Night scenarios not affected by lack of contrast.	b. Viewing angle near 90° must be utilized.
	c. Visual representations in day scenarios limited by poor image contrast.

2. CHARACTERISTIC'S SPECIFICATION: 25% to 50%

CAPABILITIES	LIMITATIONS
a. Visual flexibility in range and contact selection in day scenarios is provided.	a. Scenarios slightly limited as to size of visual contacts and ranges utilized.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

J. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contrast ratio

2. CHARACTERISTIC'S SPECIFICATION: 25% to 50%

CAPABILITIES	LIMITATIONS
b. Viewing angle can be expanded beyond that for contrast ratio of less than 25% (I.J.1).	b. Individuals with vision problems may not be able to discriminate/identify objects.
c. Intensity/resolution factors may be reduced below those required for contrast ratio of less than 25% (I.J.1).	

3. CHARACTERISTIC'S SPECIFICATION: 50% to 75%

CAPABILITIES	LIMITATIONS
a. Intensity/resolution factors in normal vision range can be utilized.	a. Grossly subnormal vision may not be able to discriminate/identify objects.
b. Visual contact definition and scenario representations not limited by contrast values.	
c. Most vision problems are not a factor in discrimination/identification at this level of contrast.	
d. Wide viewing angles can be accommodated.	

4. CHARACTERISTIC'S SPECIFICATION: Over 75%

a. Optimum contrast for visual imagery.

b. Flexibility of visual scenarios maximized.

c. Subnormal vision should be able to discriminate/identify objects.

d. Maximum viewing angles within projection system parallex/distortion limits can be utilized.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

K. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Geographic area (type)

1. CHARACTERISTIC'S SPECIFICATION: Open Sea

CAPABILITIES	LIMITATIONS
a. Contact movement is not limited by geography.	a. Navigation scenarios limited to electronic lines of position.
b. Following scenarios possible: (1) Rules of the Road (2) Collision avoidance (3) Casualty control (4) Man overboard	b. Shiphandling exercises limited to collision avoidance situations, man overboard exercises, and casualty control exercise.
c. Environmental effects can be represented.	
d. Wide flexibility in exercise complexity is available.	

2. CHARACTERISTIC'S SPECIFICATION: Coastal waters

CAPABILITIES	LIMITATIONS
a. Following scenarios possible: (1) Rules of the Road (2) Collision avoidance (3) Casualty control (4) Man overboard (5) Coastal navigation	a. Contact motion restricted by geographic configuration.
b. Environmental effects can be represented.	b. Shiphandling exercises limited to following: (1) Collision avoidance exercises. (2) Man overboard exercises (3) Changes in course and speed based on navigation information.
c. Wide flexibility in exercise complexity is available.	
d. Visual navigation scenarios are more flexible than under open sea conditions.	
e. Shiphandling training enhanced by visual image representation.	
f. Own ship movement constrained by geographic factors requiring more rapid and correct decision-making.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

K. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Geographic area (type)

3. CHARACTERISTIC'S SPECIFICATION: Harbor waters

CAPABILITIES	LIMITATION
a. Wide flexibility in the following visual exercises is possible: (1) Channel transit (2) Navigation (3) Collision avoidance (4) Casualty control (5) Ship control	a. Flexibility of man overboard exercises constrained by geography.
b. Provides surroundings for visual scenarios of maximum difficulty.	

L. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Geographic area (size)

1. CHARACTERISTIC'S SPECIFICATION: 25 square miles or less

a. Short range navigation and channel transit exercises possible in areas of this size.	a. Exercise duration is limited by size of visual area.
b. Short range collision avoidance exercises possible in areas of this size.	b. Geographic representation is limited by visual area size.
c. Shiphandling and casualty control exercises possible in areas of this size.	c. Limited visual navigation scenarios available.
	d. Own ship and contact maneuvers constrained by speed/exercise time available.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

I. SUBSYSTEM: Visual Image Display

L. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Geographic area (size)

2. CHARACTERISTIC'S SPECIFICATION: 25 square miles to 625 square miles

CAPABILITIES	LIMITATION
a. Short range navigation and channel transit exercises possible in areas of this size.	a. Exercise duration is limited by size of visual area.
b. Short range collision avoidance exercises possible in areas of this size.	b. Geographic representation is limited by visual area size.
c. Shiphandling and casualty control exercises possible in areas of this size.	c. Scenarios may be limited by time and geographic restraints.
d. Exercise durations of moderate length possible in areas of this size.	d. Close range scenarios are not realistic because of geographic scale.
e. Flexibility of all visual scenarios enhanced over 1.L.1.	
f. Own ship and contact maneuvers unrestricted by size of exercise area.	

3. CHARACTERISTIC'S SPECIFICATION: Greater than 625 square miles

CAPABILITIES	LIMITATION
a. Own ship and contact maneuvers unrestricted by size of exercise area.	a. Close range scenarios are not realistic because of geographic scale.
b. Scenarios unlimited as to time and geographic restraints.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

II. SUBSYSTEM: Image Generation

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Image source

1. CHARACTERISTIC'S SPECIFICATION: Single bulb presentation

CAPABILITIES	LIMITATIONS
a. Fixed objects can be represented during night scenarios.	a. Target motion representation extremely limited to predetermined courses and speeds.
b. Duration and color coding of navaids can be represented.	b. Manual control of lights may preclude use of large numbers of navaids and/or moving targets.
c. Overhead structures (bridges) can be represented by lights only. Overhead arc of visibility limited by physical installation.	c. Rules-of-the-Road scenarios limited to night exercises.
d. Installation may be relatively inexpensive as compared to remote projection source, and computed generated image sources. (II.A.3, and II.A.4, below).	d. Freeze, restart and/or rerun extremely limited.
e. Simplicity of design provides maximum reliability and maintainability.	e. Available scale variations are limited.
	f. No capability for environmental factor inputs.
	g. Target aspect can not be shown readily.
	h. Open loop operation required.

2. CHARACTERISTIC'S SPECIFICATION: Projections (single point sources; slide projector, movie projector, shadowgraph)

CAPABILITIES	LIMITATIONS
a. Interchangeable exercise areas available.	a. Ambient light must be minimal.
b. Ship silhouette representation is possible.	b. Edge distortion may occur dependent on number of projectors and method of projection.
c. Specific ports can be represented.	
d. Superimposition of objects possible using more than one projector.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

II. SUBSYSTEM: Image Generation

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Image source

2. CHARACTERISTIC'S SPECIFICATION: Projections (single point sources; slide projector, movie projector, shadowgraph)

CAPABILITIES	LIMITATIONS
	m. Technical system limitations (i.e.: film quality, focus capability, etc.) may limit scenario presentation.
	n. Requirement for low ambient light may require trainee dark adaption.

3. CHARACTERISTIC'S SPECIFICATION: Remote source (model/board probe/TV projector)

CAPABILITIES	LIMITATIONS
a. Specific ports can be represented visually.	a. Number of gaming areas limited by number of model boards available.
b. Duration of scenarios lengthened over projection image source (II.A.2).	b. Minimal instructor control (Canned problems).
c. Degree of mobility and number of moving targets expanded over single point source projection.	c. Change in exercise area requires new model board setup.
d. Flexible scale for visual exercise area possible.	d. Mobility of moving contacts inhibited by use of tracks.
e. Increased visual flexibility in possible scenarios.	e. Traffic ship presentation limited to models available.
f. Freeze and restart and/or rerun capability present.	f. Number of ship contacts limited by physical constraints of model board.
g. Environmental conditions (rain, snow, fog) can be introduced via TV injection.	g. Narrow angle of view requires more projectors for full screen coverage.
h. 360° presentation possible.	h. Flexible scaling may be difficult.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

II. SUBSYSTEM: Image Generation

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Image source

3. CHARACTERISTIC'S SPECIFICATION: Remote source (model/board probe/TV projector)

CAPABILITIES	LIMITATIONS
i. Target aspect can be visually represented.	i. Depth of field limits close-in (docking) exercises.
j. Geographic features realistically displayed.	j. Edge matching problems may exist due to use of multiple projectors.
k. Closed loop operation possible.	
l. Realistic depth cues available.	
m. Video insertion possible.	
n. Moderately high resolution at moderate brightness levels available.	
o. Interpositioning available.	
p. Overhead structures can be represented.	

4. CHARACTERISTIC'S SPECIFICATION: Computer generated

CAPABILITIES	LIMITATIONS
a. Introduction of multi-environmental conditions flexible as to time and degree.	a. Mix of targets/navaids dictated by computer capacity.
b. Maximum instructor control possible.	b. Imagery consists of vertical and/or horizontal segments.
c. Integration of all motion vectors (i.e., own ship, contacts, environment) possible.	c. Number of projectors required is dictated by screen configuration and projection field.
d. Wide flexibility in selection of types of contacts commensurate with computer capacity.	d. Edge matching problems may be caused by use of multiple projectors.
e. 360° visual presentation possible.	
f. Contact aspect can be visually represented.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

II. SUBSYSTEM: Image Generation

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Image source

4. CHARACTERISTIC'S SPECIFICATION: Computer generated

CAPABILITIES	LIMITATIONS
g. Wide flexibility in selection of visual exercise area exists.	
h. Closed loop operation possible.	
i. Visual scaling is inherent in computer program.	
j. Maximum visual update capability exists.	
k. Maximum capability for visual image detail exists.	
l. Visual depth of field maximized.	
m. Visual interpositioning available.	
n. Overhead structures can be represented visually to maximum extent.	

5. CHARACTERISTIC'S SPECIFICATION: CRT with infinity optics

a. High resolution is possible.	a. Reversed contrast of contacts.
b. High brightness is possible.	b. Viewing angle by trainee is critical.
c. Closed loop operation can be utilized.	c. Scaling is limited by size of screen (CRT).
d. Can be utilized with TV camera pickup or computer generated image.	d. Field continuity disturbed by CRT (window) frames.
e. Depth perception excellent with optical mirror.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

II. SUBSYSTEM: Image Generation

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Image source

5. CHARACTERISTIC'S SPECIFICATION: CRT with infinity optics

CAPABILITIES	LIMITATIONS
f. Image detail poor.	e. Narrow field of view exists.
g. Use of infinity optics lessens viewing distance required, permitting smaller wheelhouse configuration.	f. Scenarios limited by scaling.
	g. Three dimensional own ship or traffic ship motion not available.

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Image reflection

1. CHARACTERISTIC'S SPECIFICATION: Front lighted

CAPABILITIES	LIMITATIONS
a. Projectors concentrated in one area.	a. Contact motion and background scene changeability limited by physical space necessary for projectors.
b. Physical plant size can be minimized.	b. Simulator ambient light must be low.
c. Various projection methods can be utilized.	

2. CHARACTERISTIC'S SPECIFICATION: Back lighted

CAPABILITIES	LIMITATIONS
a. Increased number of objects and more scenes are possible due to increased available space for projectors, model boards, etc.	a. Care must be exercised to eliminate extraneous lights behind screen.
b. Simulator ambient light may be increased.	b. Obscuration by screen structural supports occurs.
c. Instructor control of exercise enhanced by increased capability for number of contacts and additional exercise scenes due to multiplicity of projectors.	c. Larger physical space required to accommodate projector and/or contact model movement.
	d. Visual image resolution limited by screen material selection.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

II. SUBSYSTEM: Image Generation

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Screen configuration

1. CHARACTERISTIC'S SPECIFICATION: Rectangular

CAPABILITIES	LIMITATIONS
a. Will accommodate most forward of beam scenarios.	a. Viewing angle restricted to approximately 90°.
b. Will accommodate all methods of projection.	b. Horizontal field of view limited to forward of the beam.
c. Viewing distance only restricted by size of building and screen.	c. Objects abaft the beam not visible.
d. Field of vision below the horizontal may be provided.	d. Scenarios requiring navigation astern are not possible.
	e. Man overboard drill cannot be executed completely with visual cues.

2. CHARACTERISTIC'S SPECIFICATION: Curved

CAPABILITIES	LIMITATIONS
a. Will accommodate most forward of beam scenarios.	a. Multi-projectors required resulting in possible edge matching problems.
b. Will accommodate all methods of projection.	b. Horizontal field of view limited by size and curvature of screen
c. Viewing distance only restricted by size of building and screen.	c. Objects astern not visible.
d. Field of vision below the horizontal may be provided.	d. Some shiphandling and navigation (i.e., channel transit) scenarios are limited by restricted visual field of view.
e. Horizontal field of view can be projected greater than $\pm 90^\circ$ from bow. (i.e., $\pm 120^\circ$ from bow).	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

II. SUBSYSTEM: Image Generation

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Screen configuration

3. CHARACTERISTIC'S SPECIFICATION: Cylindrical

CAPABILITIES	LIMITATIONS
a. Will accommodate most forward of beam scenarios.	
b. Will accommodate all methods of projection.	
c. Viewing distance only restricted by size of building and screen.	
d. Field of vision below the horizontal may be provided.	
e. 360^0 field of view can be presented.	
f. Objects visible astern.	
g. Scenarios involving navigation astern utilized.	

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Projector control

1. CHARACTERISTIC'S SPECIFICATION: Preset (tracked)

CAPABILITIES	LIMITATIONS
a. Simple ship maneuver scenarios may be performed.	a. Instructor control restricted to initial exercise selection and setup.
b. Flexibility of different visual exercise areas is available.	b. Rerun must be accomplished from T-Ø.
c. Freeze, restart and rerun capability exists.	c. Scenarios limited by number of programs available.
	d. Duration of exercise fixed by preset program and physical installation.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

II. SUBSYSTEM: Image Generation

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Projector control

1. CHARACTERISTIC'S SPECIFICATION: Preset (tracked)

CAPABILITIES	LIMITATIONS
	e. Contact representation and motion constrained by program.
	f. Change in exercise area and scenario requires complete stop of exercise.
	g. Back lighted screen required unless mirrors are utilized.

2. CHARACTERISTIC'S SPECIFICATION: Computer controlled (cassette)

CAPABILITIES	LIMITATIONS
a. Flexibility of ship maneuver scenarios enhanced over preset projector control.	a. Instructor control of exercise limited to computer inputs.
b. Freeze, restart, and rerun capability exists.	b. Additional instructor monitoring/control requirements may dictate a need for an additional instructor.
c. Rerun can be accomplished from any point in time.	
d. Exercise duration can be extended beyond that of the preset (tracked) projector control (II.D.1).	
e. Limited modifications to scenario and/or exercise area can be made during the exercise by video insert process.	
f. Reconstruction of exercise possible for utilization of certain training techniques.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITAIONS (CONT'D)

II. SUBSYSTEM: Image Generation

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Projector control

2. CHARACTERISTIC'S SPECIFICATION: Computer controlled (cassette)

CAPABILITIES	LIMITATIONS
g. Ship casualty imposition can be realistically integrated with other exercise parameters.	

3. CHARACTERISTIC'S SPECIFICATION: Instructor controlled (keyboard)

CAPABILITIES	LIMITATIONS
a. Optimal flexibility in scenarios and types of exercise areas is possible.	a. Additional instructors may be required.
b. Degree of scenario difficulty can be tightly controlled to meet specific training needs.	b. Complexity of equipment requires extensive training of instructor.
c. Scenario can be altered without halting the exercise.	
d. Environmental parameters can be varied throughout the exercise (i.e.: wind, fog, rain) via video injection.	
e. Length of scenarios can be extended as desired to accomplish training objectives.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS

III. SUBSYSTEM: Radar/Collision Avoidance

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Color

1. CHARACTERISTIC'S SPECIFICATION: Monochromatic

CAPABILITIES	LIMITATIONS
a. All targets presented within range scale limitations.	a. Information coding of contacts limited to shape, size, location, brightness, flash rate and alphanumerics.

2. CHARACTERISTIC'S SPECIFICATION: Multichromatic

CAPABILITIES	LIMITATIONS
a. All targets presented within range scale limitations.	a. Color must be used judiciously to avoid saturating training field beyond trainee capability to handle the displayed information.
b. Additional level of information available over monochromatic color (III.A.1), through color coding.	
c. Color coding provides increased detection and discrimination over monochromatic color (III.A.1).	
d. Stimulation of learned response possible with color coding.	

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact Motion

1. CHARACTERISTIC'S SPECIFICATION: Stationary

CAPABILITIES	LIMITATIONS
a. Visual navaids and channel representations possible.	a. Underway ship contacts cannot be represented visually.
b. Visual navigation plotting exercises possible.	b. Collision avoidance exercises with vessels not possible due to lack of visual relative motion.
c. Visual landmass representation possible.	c. Minimal visual control of exercise by instructor exists.
d. Larger number of contacts can be represented than if mobile contacts were utilized.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact Motion

1. CHARACTERISTIC'S SPECIFICATION: Stationary

CAPABILITIES	LIMITATIONS
e. Environmental effects (i.e., set and drift) can be represented.	d. Training in plotting moving contacts is not possible.
f. Training in manipulation of subsystem equipment is possible.	e. Training in recognition of moving contacts on CRT is not possible.
g. Training in image interpretation possible.	f. Equipment automatic tracking capability cannot be represented to fullest extent. (i.e., relative motion, maximum number of moving contacts, trial maneuver).
h. Training in plotting navigation features on CRT possible.	g. Instructor control of exercise limited to initial setup.
i. Most equipment technical capabilities and limitations can be represented realistically.	
j. "Flash" Rules-of-the-Road situations can be provided.	
k. "Time-lapse" pictures can be shown to enhance visualization of relative versus true motion.	

2. CHARACTERISTIC'S SPECIFICATION: One axis

CAPABILITIES	LIMITATIONS
a. Same as III.B.1 a through k, above.	a. Same as III.B.1 a through d, above.
b. Training in interpretation of moving targets on CRT is possible.	b. Trial maneuver on CAS not realistic.
c. Limited CRT automatic plotting of moving targets possible.	c. Collision avoidance scenarios limited in scope.
d. Correlation with visual scene possible.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact Motion

3. CHARACTERISTIC'S SPECIFICATION: Two axes

CAPABILITIES	LIMITATIONS
a. Visual navaids and channel representations possible.	a. Mutual contact interference could confuse trainee if too many contacts are utilized.
b. Visual navigation plotting exercises possible.	
c. Visual landmass representation possible.	
d. Environmental effects (i.e., set and drift) can be represented.	
e. Ships underway can be represented visually.	
f. Contact speed can be controlled visually by the instructor.	
g. Ship maneuver problem complexity can be upgraded over limited Rules-of-the-Road and collision avoidance scenarios.	
h. Contact numbers and types can be realistic to match scenario complexity.	
i. Relative motion has maximum flexibility.	
j. Training in manipulation of subsystem equipment is possible.	
k. Training in image interpretation possible.	
l. Training in plotting navigation features on CRT possible.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact Motion

3. CHARACTERISTIC'S SPECIFICATION: Two axes

CAPABILITIES	LIMITATIONS
m. ...st equipment technical capabilities and limitations can be represented realistically.	
n. Training in interpretation of moving targets on CRT is possible.	
o. Correlation with visual scene possible.	
p. Individual target motion to determine threat to own ship can be assessed.	
q. Trial maneuver on CAS can be utilized to fullest extent.	
r. Distinction between stationary and moving contacts maximized.	
s. Collision avoidance scenarios can be utilized to full extent.	

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Bearing coverage

1. CHARACTERISTIC'S SPECIFICATION: $\pm 90^{0}$ from bow

a. Rules-of-the-Road crossing exercises possible under low visibility conditions.	a. Numbers of contacts (including landmass) limited by exercise area scale and configuration.
b. Channel transit navigation exercises possible under low visibility conditions.	b. Objects abaft the beam not visible.
c. Multiple targets possible.	c. Extremely limited sector scan available.
d. Sector scan forward of beam available.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Bearing coverage

1. CHARACTERISTIC'S SPECIFICATION: $\pm 90^0$ from bow

CAPABILITIES	LIMITATIONS
	d. All scenarios limited by beam to beam information display.
	e. Not effective for complete Rules-of-the-Road low visibility training.

2. CHARACTERISTIC'S SPECIFICATION: $\pm 120^0$ from bow

CAPABILITIES	LIMITATIONS
a. Objects abaft the beam can be represented.	a. Objects astern cannot be represented.
b. Rules-of-the-Road crossing exercises possible under low visibility conditions.	b. Some shiphandling and navigation scenarios cannot be accommodated.
c. Channel transit navigation exercises possible under low visibility conditions.	c. Sector scan cannot be used around complete 360^0.
d. Multiple targets possible.	d. Certain low visibility scenarios limited by lack of complete 360^0 radar coverage.
e. Increased sector scan available over bearing coverage of $\pm 90^0$.	

3. CHARACTERISTIC'S SPECIFICATION: 360^0

CAPABILITIES	LIMITATIONS
a. Radar representation of all types of exercise areas is possible.	
b. Rules-of-the-Road crossing and own ship overtaking situations can be represented.	
c. Ship maneuvers unlimited in the forward direction.	
d. Objects abaft the beam can be represented.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Bearing coverage

3. CHARACTERISTIC'S SPECIFICATION: 360^{0}

CAPABILITIES	LIMITATIONS
e. Rules-of-the-Road crossing exercises possible under low visibility conditions.	
f. Channel transit navigation exercises possible under low visibility conditions.	
g. Multiple radar targets possible.	
h. Selectable sector scan available through 360^{0}.	
i. Scenarios enhanced by complete 360^{0} coverage.	

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Range coverage

1. CHARACTERISTIC'S SPECIFICATION: 0 to 5 miles only

CAPABILITIES	LIMITATIONS
a. Radar coverage for close-in, small targets possible.	a. Long range scenarios utilizing radar/CAS not possible.
b. Close-in navigation aids can be utilized.	b. Exercise area size limited during radar/CAS exercises.
c. Docking/mooring exercises possible under low visibility conditions within simulator minimum range restrictions.	c. Radar visibility less than usual height of eye visual range (100 ft = 11 miles).
d. Reduced visibility scenarios possible.	d. Duration of radar/CAS scenarios limited by range.
	e. Complexity of scenarios limited by confines of exercise area.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Range coverage

1. CHARACTERISTIC'S SPECIFICATION: 0 to 5 miles only

CAPABILITIES	LIMITATIONS
	f. Duration of segmented problems limited.

2. CHARACTERISTIC'S SPECIFICATION: 0 to 10 miles only

CAPABILITIES	LIMITATIONS
a. Radar coverage for close-in, small targets possible.	a. Ship contacts cannot be represented outside of optimum visual range.
b. Close-in navigation aids can be utilized.	
c. Docking/mooring exercises possible under low visibility conditions within simulator minimum range restrictions.	
d. Reduced visibility scenarios possible.	
e. Radar/CAS scenarios are realistic as to duration and complexity.	
f. Radar ranges equivalent to visual ranges are available.	
g. Enlarged low visibility exercise area available.	
h. Correlation with visual scene is realistic.	

3. CHARACTERISTIC'S SPECIFICATION: Greater than 10 miles

CAPABILITIES	LIMITATIONS
a. Landfall piloting exercises are more realistic.	a. Cannot be used for short range navigation and collision avoidance exercises because of large scale.
b. Acquisition of targets beyond visual range possible.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Own ship's motion

1. CHARACTERISTIC'S SPECIFICATION: One axis

CAPABILITIES	LIMITATIONS
a. Straight course screnarios possible.	a. Shiphandling skills cannot be represented or evaluated.
b. Limited Rules-of-the-Road training can be accomplished up to point of own ship maneuver.	b. Restricted waters and harbor areas cannot be utilized to best advantage.
c. Limited relative motion plotting exercises can be utilized.	c. Little opportunity for exercise control (i.e., canned programs).
d. Low visibility navigation exercise can be accommodated.	d. Changes to own ship motion limited to speed changes.
	e. Complex relative motion plotting exercises not available.
	f. Trial maneuver cannot be utilized.
	g. Collision Avoidance training not available.

2. CHARACTERISTIC'S SPECIFICATION: Two axes

CAPABILITIES	LIMITATIONS
a. Shiphandling skills can be evaluated.	a. Length of scenarios governed by size of exercise area in relation to magnitude of own ship course and speed changes.
b. Full range of ship maneuver scenario difficulty is possible.	
c. Own ship characteristics can be represented more fully.	
d. Complex relative motion plotting exercises can be utilized.	
e. Collision avoidance trial maneuver possible.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Own ship's motion

2. CHARACTERISTIC'S SPECIFICATION: Two axes

CAPABILITIES	LIMITATIONS
f. Own ship maneuvers in low visibility scenarios are unlimited.	

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: CRT resolution

1. CHARACTERISTIC'S SPECIFICATION: Less than 10 minutes of arc

CAPABILITIES	LIMITATIONS
a. Target/pip size permits accurate range and bearing readouts.	a. Detectability of small targets extremely limited.
b. Compact scope sizes can be used without degrading ability to detect and identify contacts.	b. Range of detectability of large targets limited.
	c. Contrast value should be high to facilitate detection.
	d. Visual viewing angle limited to 90^{0}.
	e. Brightness factor should be in middle range (20-50 F-L).
	f. Short viewing distances required.

2. CHARACTERISTIC'S SPECIFICATION: 10-20 minutes of arc

CAPABILITIES	LIMITATIONS
a. Optimum resolution at 30" viewing distance.	a. Visual viewing angle somewhat limited.
b. Detectability of target pip at optimum level for scope size for individual viewing.	
c. Accuracy of readings $\pm\frac{1}{2}^{0}$ and ± 500 yds.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: CRT resolution

3. CHARACTERISTIC'S SPECIFICATION: Greater than 20 minutes of arc

CAPABILITIES	LIMITATIONS
a. Radar scope size required could be used as plotting surface.	a. Radar scope size required is too large for individual viewing.
b. Best for high ambient light conditions.	b. Accuracy of range and bearing readout affected by large pip size.
c. Viewing angle can be extended to $\pm 30^{0}$ from right angle.	

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: CRT brightness

1. CHARACTERISTIC'S SPECIFICATION: Less than 20 ft Lamberts

a. Level of brightness can be effective under darkened ship conditions.	a. Ambient lighting must be reduced.
	b. Contrast ratios must be high to facilitate detection.
	c. Contact image must be large to increase detection probability.

2. CHARACTERISTIC'S SPECIFICATION: 20 to 50 ft Lamberts

a. Optimum brightness for most contacts under normal ambient lighting.	a. Visual viewing angle limited.

3. CHARACTERISTIC'S SPECIFICATION: Over 50 ft Lamberts

a. Viewing angle can be extended dependent on resolution/contrast factors.	a. Glare factor may be uncomfortable.
b. Distant viewing possible.	b. High contrast ratio required to facilitate detection.
c. High ambient light can be used.	c. May impair trainee dark adaption.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

H. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: CRT contrast

CAPABILITIES	LIMITATIONS
1. CHARACTERISTIC'S SPECIFICATION: Less than 25%	
a. Contact pip size/viewing distance ratio is critical for target detection.	a. Low background brightness required to facilitate detection. b. Weak contact; pips difficult to detect. c. Low ambient lighting needed. d. Visual viewing angle critical at 90^{o}. e. Short viewing distance. f. Large scope required for maximum resolution. g. Use of hoods or covers required.
2. CHARACTERISTIC'S SPECIFICATION: 25% to 50%	
a. Intensity/resolution factors may be reduced below a CRT contrast of less than 25%. b. Ambient lighting can be increased over CRT contrast of less than 25%. c. Other conditions being equal, a higher proportion of detection will occur than with CRT contrast of less than 25%.	a. Viewing angle critical at 90^{o}. b. Target sizes and ranges still critical for detectability. c. Viewing distance limited.
3. CHARACTERISTIC'S SPECIFICATION: 50% to 75%	
a. Viewing angle can be extended to $\pm 15^{o}$ either side of 90^{o}. b. Target pip size/viewing distance ratio not critical.	a. Intensity/resolution values are minimal factors.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

H. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: CRT contrast

3. CHARACTERISTIC'S SPECIFICATION: 50% to 75%

CAPABILITIES	LIMITATIONS
c. Viewing distance can be extended.	
d. Ambient lighting not critical.	
e. Full range of plotting and tracking exercises possible.	

4. CHARACTERISTIC'S SPECIFICATION: Over 75%

CAPABILITIES	LIMITATIONS
a. Optimum contrast.	
b. Wide range of intensity/resolution values are acceptable.	

I. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact density

1. CHARACTERISTIC'S SPECIFICATION: 1 to 5

CAPABILITIES	LIMITATIONS
a. Minimal flexibility in exercise area representation.	a. Landmass representation is nil or extremely limited.
b. Minimal Rules-of-the-Road exercises possible.	b. Number of moving contacts dependent on fixed contact requirements and vice-versa.
c. Ship tracking and plotting exercises are possible.	c. Correlation with visual scene extremely limited.
d. Reduced visibility piloting and casualty avoidance exercises possible.	
e. Instructor control of exercise is possible.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

I. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Contact density

2. CHARACTERISTIC'S SPECIFICATION: 5 to 20

CAPABILITIES	LIMITATIONS
a. Exercise area representation has moderate flexibility.	a. Number of moving contacts limited by number of fixed contacts.
b. Utilization of more moving contacts provides more complex Rules-of-the-Road and collision avoidance scenarios.	b. Landmass representation moderately limited.
c. Complex reduced visibility piloting and navigation exercises possible.	c. Correlation with visual scene will be minimal.
d. Complex ship tracking and plotting exercises possible.	
e. Instructor control of exercise enhanced above contact density of 1 to 5.	

3. CHARACTERISTIC'S SPECIFICATION: Over 20

CAPABILITIES	LIMITATIONS
a. Contact representation provides unlimited scenario complexity.	a. Contact saturation may occur, resulting in negative training.
b. Exercise area representation maximized.	b. Too great a number of contacts may inhibit manual tracking/plotting exercises.
c. Correlation with visual scene will be maximized.	
d. Instructor control of exercise maximized.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

III. SUBSYSTEM: Radar/Collision Avoidance

I. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Performance degradation

1. CHARACTERISTIC'S SPECIFICATION: Natural phenomena (ducting, lobing, fading, etc.)

CAPABILITIES	LIMITATIONS
a. Controlled realistic degradation of radar picture possible.	a. Degradation may inhibit training if not used judiciously.
b. Radar tracking/piloting exercises are more realistic.	
c. Trainee can become familiar with technical limitations of representative equipment.	

2. CHARACTERISTIC'S SPECIFICATION: Environmental interferences (rain, squalls, sea return, land clutter)

CAPABILITIES	LIMITATIONS
a. Realistic radar performance criteria can be represented to correlate with exercise parameters (i.e., high sea states, landmass representation).	a. Degradation may inhibit training if not used judiciously.
b. Realistic representation of environmental factors can result in target masking and intermittant plotting capability to provide a method of performance measurement.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ship control equipment

1. CHARACTERISTIC'S SPECIFICATION: Manual steering

CAPABILITIES	LIMITATIONS
a. Provides feel for ship response to helm orders.	a. Tiring for trainee. Rotation of watch-standers required.
b. Provides training in rudder angle selection under adverse sea and wind conditions.	b. Inexperience/lack of skill of helmsmen may degrade quality of performance of other team members in exercise.
c. Provides opportunity for performing helmsman's task and reporting of information	
d. Introduction of steering casualities can be done realistically.	
e. Training in recognition of interaction of rudder angle, turn rate and gyro indicators can be accomplished.	
f. Provides opportunity for training in radical emergency maneuvers.	
g. Rudder angle $\pm 40^{0}$ available.	
h. Turn rate to 10^{0}/sec maximum available.	

2. CHARACTERISTIC'S SPECIFICATION: Automatic steering

CAPABILITIES	LIMITATIONS
a. Skill of helmsman not a factor in evaluation of team results.	a. Scenarios limited to minimal, nonemergency course changes.
b. Combination of automatic and manual steering gives wide scenario flexibility.	b. No training in ship response to rudder angles available to trainee.
c. Recognition of steering casualty provided by off-course alarms and other alarm indicators.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ship control equipment

2. CHARACTERISTIC'S SPECIFICATION: Automatic steering

CAPABILITIES	LIMITATIONS
d. Steering control can be adjusted to existing wind and sea conditions.	
e. Less tiring for helmsman than manual control.	
f. Rudder angle $\pm 40^{\circ}$ available.	
g. Turn rate to 10°/sec maximum available.	

3. CHARACTERISTIC'S SPECIFICATION: Indirect propulsion control (i.e., engine order telegraph, voice or bell comm.)

CAPABILITIES	LIMITATIONS
a. Instructor control of exercise more precise.	a. Time lag in execution of orders exists.
b. Introduction of casualty or mistaken orders can be made realistically (i.e., wrong way alarm).	b. Possibility of error in transmission of orders.
c. Speed control 0-50 knots available.	c. Additional equipment and indicators required.
d. Reverse direction possible.	d. Using variable pitch propellers, the integration of shaft rpm and pitch control cannot be demonstrated by the trainee.
	e. Speed control should be accomplished by person other than helmsman.

4. CHARACTERISTIC'S SPECIFICATION: Direct propulsion control

CAPABILITIES	LIMITATIONS
a. Using variable pitch propellers, trainee can practice integration of shaft rpm and pitch control.	a. Trainee may move control in wrong direction.
b. Immediate response to engine orders possible.	b. Speed control should be done by person other than helmsman.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ship control equipment

4. CHARACTERISTIC'S SPECIFICATION: Direct propulsion control

CAPABILITIES	LIMITATIONS
c. Transmission errors are minimal.	c. Instructor control limited to casualty imposition.
d. Casualty control situations can be imposed.	d. The Deck Officer must be familiar with engine casualty indications and required corrective actions.
e. Speed control available 0-50 knots.	
f. Provides emergency stop control in case of engine casualty.	

5. CHARACTERISTIC'S SPECIFICATION: Thrusters

CAPABILITIES	LIMITATIONS
a. Provides capability of control for docking scenarios.	a. Additional control and indication equipment required.
b. Training in control of propeller pitch and direction is possible.	b. Additional task required of instructor to monitor instrumentation and provide feedback.
c. Lateral docking speed variable 0-1 knot.	

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Anchor equipment

1. CHARACTERISTIC'S SPECIFICATION: Remote control

CAPABILITIES	LIMITATIONS
a. Provides training in maneuvering and anchoring within specific limits (± 1 ship length).	a. Additional controls and indicators required.
b. Provides training for streaming anchor chain to suit expected weather conditions (0-50 fathoms).	b. Additional workload for instructor to provide feedback.
c. Provides training in integrating ship motion with environmental effects in letting go the anchor.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Anchor equipment

2. CHARACTERISTIC'S SPECIFICATION: No control

CAPABILITIES	LIMITATIONS
a. Trainee can notify instructor verbally to drop the anchor, and performance measurements can then be obtained from X, Y coordinate position of anchor drop.	a. Anchoring exercises cannot be carried out to completion by trainee. b. Instructor required to mark dropping point to evaluate trainee performance.

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Position fixing equipment

1. CHARACTERISTIC'S SPECIFICATION: Pelorus (visual bearings)

CAPABILITIES	LIMITATIONS
a. Number and placement of navaids can be varied to introduce complexity.	a. Can only be used when navaids are visible.
b. Reduced visibility scenarios can be introduced for complexity.	b. Requires bridge wing or centerline pelorus with gyro input.
c. Most accurate fixes obtainable $\pm$one ship length.	c. No range information available.
d. Information can be integrated with other fixing methods.	d. Navaids may be masked by other objects.
e. Danger bearing apparent visually.	e. May require special display capabilities or non-linear bearing scale to compensate for parallax error.

2. CHARACTERISTIC'S SPECIFICATION: Radar range and bearing

CAPABILITIES	LIMITATIONS
a. System degradation can be simulated for realism.	a. Accuracy of readouts dependent on range scales used.
b. Ranges on visual bearings can be obtained.	b. Large target pip size could affect bearing accuracy.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Position fixing equipment

2. CHARACTERISTIC'S SPECIFICATION: Radar range and bearing

CAPABILITIES	LIMITATIONS
c. Accuracy of $\pm 1^{o}$ and ± 0.01 mile obtainable.	
d. Navigation information can be integrated with other fixing methods.	
e. Ranges and bearings can be obtained on objects hidden visually.	

3. CHARACTERISTIC'S SPECIFICATION: Radio direction finder (bearings)

CAPABILITIES	LIMITATIONS
a. Manipulative training of equipment can be accommodated.	a. Bearing accuracy of $\pm 2^{o}$.
b. Navigation information can be obtained from navaids beyond maximum radar range.	b. No range information available.
c. Stations can be tuned in by utilizing installed radio equipment.	c. Interpretation of information received is required to eliminate ambiguity.
	d. Special RDF stimulation is required (i.e., station identification, relative bearing, frequency, etc).

4. CHARACTERISTIC'S SPECIFICATION: Loran A&C, Decca, Satellite, Omega (electronic lines of position)

CAPABILITIES	LIMITATIONS
a. Manipulative training of equipment can be accommodated.	a. Accuracy dependent on relative angles of lines of position.
b. Broad coverage of open ocean areas possible.	b. Relative placement of stations is critical for area coverage.
	c. Special charts and publications required for determining lines of position.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Position fixing equipment

4. CHARACTERISTIC'S SPECIFICATION: Loran A&C, Decca, Satellite, Omega (electronic lines of position)

CAPABILITIES	LIMITATIONS
	d. Special electronic receivers are required.
	e. Satellite equipment not broadly available at sea.

5. CHARACTERISTIC'S SPECIFICATION: Doppler log (speed over ground)

CAPABILITIES	LIMITATIONS
a. Dead reckoning navigation possible.	a. No positive fixes possible without additional navigational information.
b. More accurate dead reckoning position than that obtained from EM log.	
c. Set and drift effects integrated in readout.	
d. Information can be integrated in contour navigation.	

6. CHARACTERISTIC'S SPECIFICATION: Electromagnetic log (speed through the water)

CAPABILITIES	LIMITATIONS
a. Can be used for dead reckoning navigation.	a. Accuracy degraded by external factors (i.e., set, drift)
b. Information can be utilized in contour navigation.	
c. Distance traveled can be determined directly from the equipment.	

7. CHARACTERISTIC'S SPECIFICATION: Fathometer (soundings)

CAPABILITIES	LIMITATIONS
a. Contour navigation possible.	a. Positive fix not possible with soundings alone.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Position fixing equiment

7. ALTERNATE SUBSYSTEM CHARACTERISTIC: Position fixing equipment

CAPABILITIES	LIMITATIONS
b. Information can be integrated with other sources of navigation information.	b. Special charts required.
c. Permanent record can be display on tape.	

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Position plotting equipment

1. CHARACTERISTIC'S SPECIFICATION: Chart table

CAPABILITIES	LIMITATIONS
a. Direct plotting possible.	a. Own ship movement not automatically plotted. b.
b. Integration of various information sources possible.	b. Transposition errors possible.
c. Variety of chart types available (i.e., bottom contour, loran, decca, etc).	c. Large library of charts required.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Radar manual plotting equiment

1. CHARACTERISTIC'S SPECIFICATION: PPI display

a. Direct plot decreases transposition errors.	a. Size of plotting surface limited.
b. Contact information derived as follows: (1) Course (2) Speed (3) Closest point of approach (CPA) (4) Range tna dtme at CPA	b. Number of targets tracked is limited (1 to 5). c. Speed and accuracy of plot dependent on individual capability.
c. Casualty avoidance and navigation scenarios possible with smaller number of contacts.	d. Integration with visual navigation plot not possible.
d. Quick appreciation of threat to own ship can be made.	e. Plot scale limited to range scale. f. Accuracy dependent on range scale selected.
e. Plotting exercises possible up to maximum radar range.	g. Reduced visbility scenarios are limited.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Radar manual plotting equipment

1. CHARACTERISTIC'S SPECIFICATION: PPI display

CAPABILITIES	LIMITATIONS
f. Own ship course and speed input automatic.	h. Permanent navigation plot not available.
g. Accuracy available (1) Bearing (a) $\pm 2^{o}$ @ 20 miles (b) $\pm 1^{o}$ @ 10 miles (c) $\pm \frac{1}{2}^{o}$ @ 5 miles (2) Range (a) $\pm 5\%$ @ 20 miles (b) $\pm 2.5\%$ @ 10 miles (c) $\pm 1\%$ @ 5 miles	

2. CHARACTERISTIC'S SPECIFICATION: Chart table

CAPABILITIES	LIMITATIONS
a. Plot scale is flexible.	a. Possibility of transposition error.
b. Integration with visual plot enhanced.	b. Own ship track must be plotted along with targets.
c. Expandable plotting surface exists.	c. Number of targets tracked is limited (1 to 5).
d. Contact information derived as follows: (1) Course (2) Speed (3) Closest point of approach (CPA) (4) Range and time at CPA	d. Speed and accuracy of plot dependent on individual capability.
e. Casualty avoidance and navigation scenarios possible with small number of contacts.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Radar manual plotting equipment

2. CHARACTERISTIC'S SPECIFICATION: Chart table

CAPABILITIES	LIMITATIONS
f. Plotting exercises possible up to maximum radar range.	
g. Accuracy limits determined by capability of radar being utilized (see 4.E.1, item g).	
h. Permanent navigation plot available.	

3. CHARACTERISTIC'S SPECIFICATION: Dead reckoning tracer

CAPABILITIES	LIMITATIONS
a. Automatic own ship course and speed input.	a. Possibility of transposition error exists.
b. Variable scale selection exists.	b. Number of targets tracked is limited (1 to 5).
c. Integration with visual plot enhanced.	c. Speed and accuracy of plot dependent on individual capability.
d. Expandable plotting surface possible.	
e. Same as IV.E.1.b through g, above.	
f. Reduced visibility scenarios of moderate complexity can be utilized.	
g. Permanent navigation plot available.	

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: CAS automatic plotting equipment

1. CHARACTERISTIC'S SPECIFICATION: CAS PPI display

CAPABILITIES	LIMITATIONS
a. Provides following selectable alarm capability. (1) Minimum range (2) Minimum CPA (3) Contact acquisition	a. Alarms can detract from training effort if not set to proper limits. b. Trainee can be distracted by operation of CAS to exclusion of other cues during exercise.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: CAS automatic plotting equipment

1. CHARACTERISTIC'S SPECIFICATION: CAS PPI display

CAPABILITIES	LIMITATIONS
b. Multi-contact tracking possible.	c. Limited to capability of radar being utilized.
c. Trial maneuver can be utilized prior to initiating own ship course change.	d. Possible contact saturation in high traffic areas.
d. Contact information available in minimal time.	e. Permanent navigation plot not available.
e. Same as IV.E.1.b through g.	
f. Transposition errors do not occur.	
g. Contact course can be plotted to $\pm 5^0$ at 10 miles.	
h. Contact speed can be plotted to ± 2 knots at 10 miles.	
i. Maximum correlation with visual scene.	
j. Reduced visibility scenarios can be made complex.	

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Radar/CAS control and indication equipment

1. CHARACTERISTIC'S SPECIFICATION: Actual components

a. Trainee obtains positive training in manipulation of controls and interpretation of indication and readouts.	a. Computer and/or instructor must input proper signals to equipment.
b. Variety, flexibility and complexity of scenarios and gaming areas are maximized.	b. Necessity for automatic signal input may limit computer capacity in other areas.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Radar/CAS control and indication equipment

1. CHARACTERISTIC'S SPECIFICATION: Actual components

CAPABILITIES	LIMITATIONS
c. Performance measurement of equipment operation is possible.	
d. Degradation of equipment performance can be utilized realistically.	
e. Use of actual equipment enhances realism of surroundings for trainee.	
f. Automatic signal inputs may decrease instructor workload.	
g. Trial maneuver can be accomplished.	

2. CHARACTERISTIC'S SPECIFICATION: Simulated components

CAPABILITIES	LIMITATIONS
a. Instructor can provide information verbally which may not be provided by installed equipment.	a. Realism of bridge surroundings is degraded.
	b. Trainee may receive negative training from simulated component.
	c. Variety, flexibility, and complexity of scenarios and exercise areas may be degraded.
	d. Performance measurement of equipment operation limited by installed equipment.
	e. Instructor workload will be increased proportionately to the amount of information he is required to provide.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

H. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: External communications equipment

1. CHARACTERISTIC'S SPECIFICATION: UHF/VHF radio transceiver

CAPABILITIES	LIMITATIONS
a. Ship-to-ship communication possible.	a. Range is limited. Useful only in line-of-sight situations.
b. Harbor control circuit can be monitored.	b. Radio crosstalk may degrade training in pilothouse.
c. Pilot/tug call-up possible.	c. Instructor control of circuits essential.
d. Can provide training in radio procedure and terminology.	d. Atomospherics may limit range and clarity.
e. Can be included in casualty control situation.	e. Dependent on ship's electric power supply.
f. Provides method for instructor control of exercise.	f. Use of simulated equipment would inject artificiality into exercise.
g. Use of actual equipments will inject realism into exercise.	

2. CHARACTERISTIC'S SPECIFICATION: Walkie-talkie radio transceiver

CAPABILITIES	LIMITATIONS
a. Ship-to-tug communication capability.	a. Short range.
b. Direct bridge-to-anchor control communication capability.	b. Environmental disturbance possible (i.e., wind, rain).
c. Facilitates training in tug handling/ anchoring scenarios.	c. Use of simulated equipment would inject artificiality into exercise.
d. Use of actual equipment will inject realism into exercise and enhance bridge surroundings.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

H. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: External communications equipment

3. CHARACTERISTIC'S SPECIFICATION: Bridge radio weather facsimile receiver

CAPABILITIES	LIMITATIONS
a. Can be utilized to inject weather early warning into appropriate scenarios.	a. Adds additonal task to instructor controlling exercise.
b. Provides additional facet of instructor control of exercise.	b. Use of simulated equipment would inject artificiality into exercise.
c. Should provide additional factor to be considered in decision making role.	c. Could increase instructor workload.
d. Use of actual equipment will inject realism into exercise and enhance bridge surroundings.	

I. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Interior communication equipment

1. CHARACTERISTIC'S SPECIFICATION: Sound-powered telephones

CAPABILITIES	LIMITATIONS
a. Provides communication between multiple ship control stations.	a. May require use of additional personnel to man circuit during casualty control drills.
b. Provides a system for monitoring and correcting shipboard casualties.	b. Fixed location of handsets may cut down mobility of Deck Officer.
c. Headsets may be provided for casualty control situations to provide mobility of individual.	c. Use of simulated equipments would inject artifically into exercise.
d. Provides a method for instructor control of exercise.	
e. Can be utilized as back-up system for walkie-talkie during anchoring scenarios.	
f. Provides backup engine control system in case of electric power loss.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

I. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Interior communication equipment

1. CHARACTERISTIC'S SPECIFICATION: Sound-powered telephones

CAPABILITIES	LIMITATIONS
g. Use of actual equipments will enhance bridge realism.	

2. CHARACTERISTIC'S SPECIFICATION: Electronic intercom (i.e., talk back)

CAPABILITIES	LIMITATIONS
a. Provides quick response system between various sections of ship.	a. Alarm/MC system must have priority assignments and/or cutouts.
b. Provides method of alerting ship to casualty situations (i.e., collision, fire, etc).	b. Dependent on ship's power supply.
c. Battery power may be supplied for alarm systems to provide signals during loss of power situations.	c. Use of simulated equipments would inject artificialities into exercise.
d. Can assist in casualty control problem sequencing by instructor.	d. Use of intercom can increase instructor workloads.
e. Use of actual equipments will enhance bridge realism.	

3. CHARACTERISTIC'S SPECIFICATION: Dial telephone

CAPABILITIES	LIMITATIONS
a. Provides system for passing administrative information from instructor to trainee or simulator operator.	a. Is dependent on ship's electric power.
b. Can be utilized for passing non-emergency information between multiple ship spaces.	b. Use of simulated equipment would inject artificialities into exercise.
	c. Use of telephone for exercise purposes can increase instructor workload.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

I. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Interior communication equipment

3. CHARACTERISTIC'S SPECIFICATION: Dial telephone

CAPABILITIES	LIMITATIONS
c. Can be utilized for passing emergency information if sound powered telephone is not available at specific location.	
d. Use of actual equipment enhances bridge realism.	

4. CHARACTERISTIC'S SPECIFICATION: TV monitor

CAPABILITIES	LIMITATIONS
a. Provides monitoring of certain spaces for casualty identification and control.	a. Scope of coverage may be limited by fixed TV monitor field of view.
b. Provides extra safety precaution for bow lookout station.	
c. Provides safety monitoring of anchor station during anchoring situations.	

J. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ship systems alarms (gyro, steering, electrical power, propulsion (auxiliary equipment), running light panel)

1. CHARACTERISTIC'S SPECIFICATION: Instructor initiated

CAPABILITIES	LIMITATIONS
a. Casualty control scenarios can be initiated by instructor.	a. Extent and number of casualties must be controlled to provide proper level of training.
b. Selection of type, number, and severity of casualties can be tightly controlled.	b. Additional task is imposed on the instructor.
c. Timing of casualty is flexible.	
d. Casualty control exercise sequencing is flexible.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

J. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ship systems alarms (gyro, steering, electrical power, propulsion (auxiliary equipment), running light panel)

1. CHARACTERISTIC'S SPECIFICATION: Instructor initiated

CAPABILITIES	LIMITATIONS
e. Effective counteraction can be taken immediately.	
f. Alarm system can utilize battery emergency power.	

2. CHARACTERISTIC'S SPECIFICATION: Programmed or automatic

CAPABILITIES	LIMITATIONS
a. Timing can be preintegrated in scenario.	a. Correction of casualty must be completed during time allotted by scenario.
b. Scenarios can be constructed to provide specific alarm situations under specific conditions.	b. Alarm overlap could occur.
c. Casualty control exercise sequencing possible.	c. Instructor control of exercise limited to selection of scenario.
d. Instructor can devote additonal time to other aspects of training.	d. Alarm system could be affected by loss of electrical power.
e. Effective counteraction can be taken immediately.	
f. Alarm system can utilize battery emergency power.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

K. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Situation alarms (fire, collision or flooding, off course, collision avoidance system (detection of contact, contact minimum range, and CPA minimum range), wrong way, least depth, and radio)

1. CHARACTERISTIC'S SPECIFICATION: Instructor initiated

CAPABILITIES	LIMITATIONS
a. Casualty control scenarios can be initiated by instructor.	a. Extent and number of casualties must be controlled to provide proper level of training.
b. Selection of type, number, and severity of casualties can be tightly controlled.	b. Additional task is imposed on the instructor.
c. Timing of casualty is flexible.	
d. Casualty control exercise sequencing is flexible.	
e. Effective counteraction can be taken immediately.	
f. Alarm system can utilize battery emergency power.	
g. Deck Officer can determine ship contact threat probability in short period of time.	
h. Trial maneuver can be executed prior to immediate danger to own ship.	
i. Steering errors during shiphandling exercises can be detected by Deck Officer automatically.	

2. CHARACTERISTIC'S SPECIFICATION: Programmed or automatic

CAPABILITIES	LIMITATIONS
a. Same as IV.J.2. a through f, above.	a. Same as IV.J.2. a through d, above.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

K. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Situation alarms (fire, collision or flooding, off course, collision avoidance system (detection of contact, contact minimum range, and CPA minimum range), wrong way, least depth, and radio)

2. CHARACTERISTIC'S SPECIFICATION: Programmed or automatic

CAPABILITIES	LIMITATIONS
b. Same as IV.K.1. c through i, above.	b. Same as IV.K.1.a above.

L. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Indication equipments (ship control, propulsion, speed and distance, weather, water depth, navigation light panel, ship dynamics (clinometer), ballast control)

1. CHARACTERISTIC'S SPECIFICATION: Actual components

CAPABILITIES	LIMITATIONS
a. Trainee obtains positive training in reading and interpreting actual state-of-the-art components.	a. Necessity for automatic signal inputs may limit computer capacity in other areas.
b. Indicators can be easily interfaced with associated systems equipment.	b. Manual instructor inputs would limit the number and update rate of required signals.
c. Reading and interpretation of indicator readouts can be utilized as part of performance measurements.	
d. Use of actual components enhances the realism of bridge surroundings.	
e. Degradation of equipment performance and/or failure can be represented realistically enhancing the quality of trainee performance measurements.	
f. Automatic signal inputs may decrease instructor workload.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equipment Configuration

L. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Indication equipments (ship control, propulsion, speed and distance, weather, water depth, navigation light panel, ship dynamics (clinometer), ballast control)

1. CHARACTERISTIC'S SPECIFICATION: Actual components

CAPABILITIES	LIMITATIONS
g. Casualty control exercise can be structured with more flexibility (i.e., indicator failure versus equipment failure).	
h. Presence of finite readings on indicators enhances the ability to set performance standards.	
i. Positive transfer of training to shipboard installations will occur.	
j. Trainee self-evaluation of performance enhanced by realistic information update.	

2. CHARACTERISTIC'S SPECIFICATION: Simulated components

a. Information can be passed verbally by instructor station.	a. Verbal transmission of information can increase instructor workload.
b. Off-the-shelf indicators may be substituted for sophisticated system component indicators.	b. Workload increase may require two instructor/operators.
c. Decrease in requirement for computer signal input may provide increased computer capacity in other areas.	c. Interface with system components may require equipment component modification.
	d. Absence of actual system indicators may inhibit performance measurement of trainee.
	e. Use of substitute indicators may degrade realism of bridge surroundings.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IV. SUBSYSTEM: Bridge Equpment Configuration

L. ALTERNATE SUBSYSTEM CHARACTERISTIC: Indication equipments (ship control, propulsion, speed and distance, weather, water depth, navigation light panel, ship dynamics (clinometer), ballast control)

2. CHARACTERISTIC'S SPECIFICATION: Simulated components

CAPABILITIES	LIMITATIONS
	f. Flexibility of casualty imposition is degraded.
	g. Lack of finite, realistic indicator readings will inhibit trainee self-evaluation of performance.
	h. Negative transfer of training may occur upon return to shipboard environment.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

V. SUBSYSTEM: Audio

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: External sources (environment, wind or sea, other ship signals, navaids, sea birds)

1. CHARACTERISTIC'S SPECIFICATION: No auditory cues

CAPABILITIES	LIMITATIONS
a. No distraction for trainees.	a. Lack of audible cues could affect scenario realism.
b. Primary training methods would be emphasized (i.e., visual identification).	b. Lack of navaid sounds may degrade low visibility navigation problems.
c. Instructor tasks are less than if auditory cues were utilized.	c. Low visibility Rules-of-the-Road scenarios would not be as realistic as if auditory navaid cues were available.
	d. Confirmation of radar information may be difficult under low visibility conditions.
	e. Training in use of audible signals could not be given.
	f. Lack of cues to signify changes in weather conditions would exist (e.g., wind, wave slap).
	g. Number and types of navaids available for use during low visibility condition is limited.

2. CHARACTERISTIC'S SPECIFICATION: Auditory cues

CAPABILITIES	LIMITATIONS
a. Adds realism to low visibility scenarios.	a. Multiplicity of ship/navaids sounds may prove to be distracting to trainee.
b. Assists in identification of navigation aids in night and low visibility scenarios.	b. Instructor must be judicious in choosing intensity levels to reflect relative distance of various noise sources.
c. Confirmation of radar targets during low visibility scenarios is possible.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

V. SUBSYSTEM: Audio

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: External sources (environment, wind or sea, other ship signals, navaids, sea birds)

2. CHARACTERISTIC'S SPECIFICATION: Auditory cues

CAPABILITIES	LIMITATIONS
d. Moderate to extreme environmental conditions can be cued audibly (e.g., rain, wind, waves).	c. Audible cues must be carefully integrated with environmental effect on own ships motion.
e. Would provide important identifying cues in Rules-of-the-Road exercises (e.g., other ship whistle signals).	d. Navaid auditory cues may become masked by environmental sounds.
f. Types and numbers of navaids available for use under low visibility conditions are maximized.	e. Instructor tasks will be increased by necessity to provide audible cues.

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Internal sources (engines, ventilation blower, communications "chatter", own ship signals and alarms, own ship "working", propeller, MC system, deck gear (anchor))

1. CHARACTERISTIC'S SPECIFICATION: No auditory cues

a. Communication can be maintained with sound powered transmission on hand held receivers.	a. Casualty control exercise initiation restricted to visual alarms.
b. Casualty control scenarios can be performed by using ship motion and control as cues.	b. Lack of realistic surroundings in pilot house exists.
c. Instructor tasks are less than if auditory cues were utilized.	c. Auxiliary machinery auditory cues for casualty situations missing (e.g., loss of elect. power).
	d. Own ship signals under Rules of the Road must be assumed.
	e. Audible cues not available for anchoring or lifeboat exercises.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

V. SUBSYSTEM: Audio

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Internal sources (engines, ventilation blower, communications "chatter", own ship signals and alarms, own ship "working", propeller, MC system, deck gear (anchor))

2. CHARACTERISTIC'S SPECIFICATION: Auditory cues

CAPABILITIES	LIMITATIONS
a. Adds realism to pilot house surroundings.	a. Intensity levels of noise must be tightly controlled to prevent trainee confusion and masking of training objectives.
b. Permits communication monitoring in a realistic manner.	b. Instructor is involved in monitoring/controlling auditory cues.
c. Auditory cues for ship casualties available.	c. Auditory cues must be integrated with own ship's operational situation.
d. Training in Rules-of-the-Road ship signals can be provided.	
e. Auditory cues can be coupled with own ship motion and visual cues.	
f. Auditory cues can be utilized for situational and ship system alarms.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VI. SUBYSYSTEM: External Factors

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Visibility (rain, fog, snow, night, twilight)

1. CHARACTERISTIC'S SPECIFICATION: Static or fixed for any given exercise

CAPABILITIES	LIMITATIONS
a. Provides training at a specific level required for any specific exercise.	a. Scenario limited by visibility condition throughout exercise.
b. Can provide visibility limits from zero to unlimited.	b. Instructor control limited to initial visibility setting.
	c. Scenarios must be programmed around chosen visibility conditions.
	d. Complexity of scenarios limited by visibility settings.

2. CHARACTERISTIC'S SPECIFICATION: Variable within given exercise

CAPABILITIES	LIMITATIONS
a. Provides training at a specific level required for any specific exercise.	a. Instructor required to provide additional inputs to the problem thereby increasing his workload.
b. Can provide visibility limits from zero to unlimited.	
c. Instructor control of exercise enhanced by ability to inject visibility changes during exercises.	
d. Scenario complexity enhanced.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VI. SUBSYSTEM: External Factors

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Set and drift

1. CHARACTERISTIC'S SPECIFICATION: Set 0^0 to 360^0, drift 0 to 10 knots, wind 0 to 50 knots, current 0 to 5 knots

CAPABILITIES	LIMITATIONS
a. Values may be representative for own ship characteristics.	a. Must be calculated by computer or entered by keyboard for realistic values.
b. Ship block coefficient can be factored in.	b. Values must be correlated with existing environmental conditions.
c. Wind and/or current can be calculated independently.	
d. Tidal condition may be represented.	
e. Realism and complexity is injected in various shiphandling and navigation exercises.	
f. Provides additional factor for instructor control of exercise.	

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Sea state

1. CHARACTERISTIC'S SPECIFICATION: State 0 to 5

CAPABILITIES	LIMITATIONS
a. Values of sea state can be coupled with parameter of own ship motion base or visual parameters.	a. Should be integrated with ship motion parameters (i.e., pitch, roll, heel).
b. Provides additional realism factor.	b. Magnitude of effects on own ship by various sea states should be provided with realism and accuracy to reflect exercise situation.
c. Provides additional instructor control factor.	
d. Provides swell and/or surge conditions in harbor.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VI. SUBSYSTEM: External Factors

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Tugs

1. CHARACTERISTIC'S SPECIFICATION: 1 to 5 units of force

CAPABILITIES	LIMITATIONS
a. Provides capability to maneuver ship in restricted geographic situations.	a. Tug force values must be integrated with other external force values.
b. Permits mooring and docking scenarios up to point of simulator minimum range.	b. Because of continuously varying tug maneuvers, forces must be calculated by computer.
c. Permits complex shiphandling scenarios in harbor waters.	c. Representation of tug requires additional equipment capabilities in multiple subsystems.
d. Deep sea breakdown and towing scenarios can be utilized.	

TALBE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VII. SUBSYSTEM: Motion Base

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Stationary

1. CHARACTERISTIC'S SPECIFICATION: Zero motion

CAPABILITIES	LIMITATIONS
a. Change in own ship head can be represented visually.	a. Lack of realism in representation of own ship motion under certain environmental conditions exists.
b. Primary training objectives are not degraded by own ship motion.	b. Lack of vestibular cues during shiphandling exercises exists.
c. Yaw resulting from environmental factors can be represented visually.	
d. Pitch and roll can be represented visually utilizing computer program.	

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Motion

1. CHARACTERISTIC'S SPECIFICATION: Pitch, roll, heave

CAPABILITIES	LIMITATIONS
a. Vestibular response adds realism to the effects of environmental factors during shiphandling exercises.	a. Own ship motion may interfere with primary training objectives.
b. Motion can be coupled with visual effects to represent greater magnitude if desired.	b. Magnitude of motion must be controlled to prevent adverse effects on trainees.
c. Instructor has additional method of control over exercise complexity.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VIII. SUBSYSTEM: Control Mode

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Time scale

1. CHARACTERISTIC'S SPECIFICATION: Normal time

CAPABILITIES	LIMITATIONS
a. Scenarios represent actual situations under existing ship speed constraints.	a. Complexity of exercise cannot be enhanced by upgrading decision/response times required in specific situations.
b. Replay of exercise for performance feedback or experience enhancement will be under same parameters as initial exercise.	b. During replay of exercise, time cannot be increased to bypass exercise segments not desired for replay.
	c. Retrieval of stored data for critique purposes cannot be accomplished other than in real time.

2. CHARACTERISTIC'S SPECIFICATION: Fast time

a. Undesired exercises segments can be quickly bypassed during replay.	a. Realism can be degraded by nonjudicious use of fast time.
b. Complexity of specific exercise segments can be enhanced by speeding up required decision/response times.	
c. Retrieval of stored data can be accelerated for critique purposes.	

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Start-restart

1. CHARACTERISTIC'S SPECIFICATION: Initial point (T+Ø)

a. Replay of entire exercise possible.	a. Unnecessary time expended if specific segment in middle of scenario is desired or if exercise has been frozen for critique purposes.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VIII. SUBSYSTEM: Control Mode

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Start/restart

1. CHARACTERISTIC'S SPECIFICATION: Initial point (T+Ø)

b. Immediate repetition, performance feedback and post problem critique training techniques can be utilized.	

2. CHARACTERISTIC'S SPECIFICATION: Variable points in scenario (T+?)

a. Replay of specific segments for critiquing or reinforcement purposes can be quickly utilized.	a. Identification of start/restart points must be done using problem time.
b. Variable start points within the scenario permits use of performance or positive guidance training techniques at any time during the exercise.	b. Too frequent use of performance feedback or guidance techniques can degrade exercise continuity.
c. Freezing of problem does not require complete rerun of previous segment to resume exercise.	

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Freeze

1. CHARACTERISTIC'S SPECIFICATION: Specific time points

a. Data points can be selected to provide optimum training method selection.	a. Performance feedback and positive guidance techniques are restrained to specific points in the scenario.
b. Duration of freeze time can be an independent variable to give instructor flexibility in training methods.	b. Sequencing of exercise segments is constrained by specific points in time.
c. Sequencing of exercise segments can be emphasized.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS(CONT'D)

VIII. SUBSYSTEM: Control Mode

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Freeze

2. CHARACTERISTIC'S SPECIFICATION: Variable time points

CAPABILITIES	LIMITATIONS
a. Instructor training enhanced by ability to apply performance feedback or positive guidance at any point in scenario.	a. Multiplicity of freeze points may destroy continuity of exercise.
b. Sequencing of exercise segments can be flexible to fit instructor training method requirements.	

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Record

1. CHARACTERISTIC'S SPECIFICATION: Selected portion of scenario only

a. Permanent data record can be made of selected segements for subsequent instructor post problem critique.	a. Length of recorded segment limited by time and/or data points.
b. Selected segments can be utilized as pre-training familiarization programs if desired.	b. Segments selected must support specific training objectives.
c. Entire exercise need not be recorded to enable critique of specific isolated exercise segments.	c. Entire scenario cannot be rerun for post problem critique purposes.
	d. Recorded segment length is critical to effectiveness of playback techniques.
	e. Data collection capacity may be limited.

2. CHARACTERISTIC'S SPECIFICATION: In total

a. Unlimited recording provides performance feedback/playback for instructor critique.	a. Length and/or continuity of exercise segments may be constrained by recording time capability.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VIII. SUBSYSTEM: Control Mode

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Record

2. CHARACTERISTIC'S SPECIFICATION: In total

CAPABILITIES	LIMITATIONS
b. Permanent data record can be taken for subsequent replay as necessary.	
c. Permanent data can be compiled concerning specific training requirements at given levels of trainee input characteristics.	

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Playback segmentation

1. CHARACTERISTIC'S SPECIFICATION: Selected segments only

CAPABILITIES	LIMITATIONS
a. Recorded data of selected segments can be recalled for critiquing purposes.	a. Entire scenario cannot be rerun for post problem critique purposes.
b. Entire exercise need not be recorded/played back to illustrate/critique specific isolated exercise segments.	b. Segments must be carefully selected to support training objectives.
	c. Segment length is critical to effectiveness of playback instructional techniques.

2. CHARACTERISTIC'S SPECIFICATION: In total

CAPABILITIES	LIMITATIONS
a. Entire scenario can be rerun using recorded data to permit post problem critique of trainee decision making.	a. Length of scenario may be constrained by playback time capability.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VIII. SUBSYSTEM: Control Mode

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Playback time

1. CHARACTERISTIC'S SPECIFICATION: Normal

CAPABILITIES	LIMITATIONS
a. Capability to rerun exercise (with freeze option) for use in post problem critique of trainee decision making.	a. Unwanted exercise segments cannot be quickly bypassed for access to required segments.
b. Capability to rerun/freeze exercise in normal time for performance feedback techniques.	b. Overspeed reruns of certain scenarios for time economy purposes not possible.

2. CHARACTERISTIC'S SPECIFICATION: Fast

CAPABILITIES	LIMITATIONS
a. Undesired segments of exercise can be by-passed as desired by the instructor to provide performance feedback and post exercise critiques.	a. Fast speed playback/rerun should be utilized judiciously to reinforce specific training objectives.
b. Opportunity to rerun entire exercise at selected overspeeds (2:1, 4:1) is provided to critique trainee decision making.	

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Exercise duration

1. CHARACTERISTIC'S SPECIFICATION: 0 to 2 hours

CAPABILITIES	LIMITATIONS
a. Selected scenarios can be accommodated within this time frame.	a. Transition between segmented scenarios is difficult due to lack of time.
b. Short exercises provide more opportunity for performance feedback/post problem critique instruction over a given instruction period.	b. Most "real world" situations requiring decision making of those magnitudes would be of longer duration.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VIII. SUBSYSTEM: Control Mode

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Exercise duration

1. CHARACTERISTIC'S SPECIFICATION: 0 to 2 hours

CAPABILITIES	LIMITATIONS
c. Exercises can be segmented realistically by specific operating areas.	
d. Short exercises may limit requirements for freeze/restart capability.	
e. Short exercises may eliminate requirement for "fast" time.	
f. Short exercises could be utilized for pre-training demonstration purposes.	
g. Short exercises lend themselves more readily to additional training techniques.	

2. CHARACTERISTIC'S SPECIFICATION: 2 to 4 hours

CAPABILITIES	LIMITATIONS
a. Wider range of selected scenarios possible.	a. Lengthy scenarios such as landfall/channel transit exercises may not be possible in real time.
b. Time span of four hours is realistic representation of one complete watch.	b. Length of exercise may inhibit ability of instructor to thoroughly critique a complete exercise.
	c. "Fast" time may be required for record/playback capability to permit critiquing of exercise segments.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

VIII. SUBSYSTEM: Control Mode

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Exercise duration

3. CHARACTERISTIC'S SPECIFICATION: Over 4 hours

CAPABILITIES	LIMITATIONS
a. Lengthy scenarios can be accommodated.	a. Critiquing of exercise may be lengthy process unless selected segments are utilized.
b. Length of exercise is realistic with "real world" master/pilot, landfall/channel transit situations.	b. Certain training methods/techniques cannot be utilized without destroying exercise continuity.
c. Large number of training situations can be included in scenario with realistic operation area transition zones.	c. "Fast" time may be required to provide flexibility for record/playback critique capability.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Wheelhouse

1. CHARACTERISTIC'S SPECIFICATION: Fixed equipment modules

CAPABILITIES	LIMITATIONS
a. Layout familiarization requirement for trainee is minimized.	a. Change of pilothouse layouts to represent various ship types is complex and costly.
b. "Off-the-shelf" manufactured components can be utilized.	b. Layout may not correspond to bridge with which trainee is familiar.
c. Use of "real" equipment provides realism for training in manipulative tasks.	c. Transference of training may be inhibited if simulator bridge is significantly different from "real world" ship.
d. Use of "real" equipment provides knowledge and training in equipment capabilities and limitations.	d. Modification and/or extension of equipments may require relocation of components.
e. Use of "real" equipment follows previous industry acceptance and a degree of acceptance of existing human engineering design criteria.	e. Modifications to components could interfere with training objectives.
	f. Fixed location must be designed to optimize human engineering concepts.

2. CHARACTERISTIC'S SPECIFICATION: Portable equipment

CAPABILITIES	LIMITATIONS
a. Multiple ship bridge types can be represented.	a. Transference of skills to "real" equipment may be inhibited.
b. Research into human engineering of control and indication equipment arrangements can be accommodated.	b. Structural changes to mockup may be necessary to support multiple locations.
c. Modification, rearrangement, extension, and/or incorporation of new instruments can be accommodated.	c. Power and signal transmission cables must support multiple component locations.
d. Functional locations of specific equipment controls and indicators can be optimized.	d. Time required to modify components may interfere with training.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Wheelhouse

3. CHARACTERISTIC'S SPECIFICATION: Portacabins (complete modules)

CAPABILITIES	LIMITATIONS
a. Rapid change in bridge representations possible.	a. Number of ship type representations constrained by number of modules available.
b. Modular construction simplifies power and signal cable arrangements.	
c. Representation of various ship types maximized.	
d. Modifications can be made "off hull" so that training is not interrupted.	

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Instructor station

1. CHARACTERISTIC'S SPECIFICATION: Integrated with wheelhouse

CAPABILITIES	LIMITATIONS
a. Proximity of instructor to trainee permits positive guidance and performance feedback of maximum capability.	a. Instructor and/or T/D operators provide distraction for trainee.
b. Observation of trainee by instructor is unrestricted.	b. Training device control equipment may intrude into bridge structure degrading realistic surroundings.
	c. Exercise realism may be degraded.
	d. Exercise communication not realistic since T/D operator is in close proximity to trainee.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Wheelhouse

1. CHARACTERISTIC'S SPECIFICATION: Integrated with wheelhouse

CAPABILITIES	LIMITATIONS
	e. Actions and/or decision making of trainee may be inhibited by presence of instructor.

2. CHARACTERISTIC'S SPECIFICATION: Separate from wheelhouse

CAPABILITIES	LIMITATIONS
a. Integrity of wheelhouse realism maintained.	a. Means of trainee observation must be provided (i.e., one-way mirror, closed circuit TV, etc).
b. Trainee not distracted by instructor/operator.	b. Remote location of instructor requires use of freeze and playback techniques to provide performance feedback and post-exercise critique training.
c. Exercise realism enhanced by use of realistic communication systems.	

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Observation/evaluation station

1. CHARACTERISTIC'S SPECIFICATION: Integrated with other facilities (i.e., wheelhouse/instructor station)

CAPABILITIES	LIMITATIONS
a. Observer/trainee interface permits close evaluation of subject responses and/or decision making.	a. Trainee performance may be inhibited if evaluator is in view.
b. Close proximity permits observer to ascertain rationale for decision made by trainee.	b. Integration with operator station may interfere with both operation and evaluation functions.
c. If integrated with instructor station, dual use can be made of viewing equipment, recorders, communications, etc.	c. Individual equipment for close unobtrusive personal observation of subject may not be available (i.e., controllable closed circuit TV cameras.).

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Observation/evaluation station

1. CHARACTERISTIC'S SPECIFICATION: Integrated with other facilities (i.e., wheelhouse/instructor station)

CAPABILITIES	LIMITATIONS
d. Observation station in wheelhouse could provide better coverage in all overall team training and evaluation exercises where more than one individual is involved.	d. Number of observers/evaluators/record keepers may be limited by space.

2. CHARACTERISTIC'S SPECIFICATION: Separated from other facilities

CAPABILITIES	LIMITATIONS
a. Dedicated station can provide equipment and observers for specific detailed observation for either training or research and evaluation.	a. Observation/evaluation of trainee is limited by method used to observe (i.e., TV camera, one way mirror, etc.).
b. Observation of trainee can be accomplished without interfering with training device instructors or operators.	b. Close evaluation of individual and group responses and decision making may be inhibited by remote location and lack of complete instrument and/or communication coverage.
c. Observation of trainee can be accomplished without inhibiting subject responses or decision making.	
d. Dedicated observation equipment frees other equipment (i.e., TV monitors) for training purposes.	
e. Dedicated space provides additional room to permit one to one observer/trainee ratio.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Classrooms

1. CHARACTERISTIC'S SPECIFICATION: Lecture only

CAPABILITIES	LIMITATIONS
a. Group instruction/orientation lectures can be tailored to large numbers of trainees.	a. Training limited to verbal lectures with possible audio-visual aid support.
b. Lecture sessions can be utilized to give flexibility in scheduling training device operations.	b. Individual practical training on part-task training device (i.e., radar tracker) cannot be accomplished.
	c. Group training in practical manipulative skills cannot be accomplished.
	d. Instructor time and effort cannot be utilized on a group basis for manipulative skills.

2. CHARACTERISTIC'S SPECIFICATION: Lecture and individual training device capability

CAPABILITIES	LIMITATIONS
a. Part-task training can be accommodated on individual training devices.	a. Individual training devices may require space needed for other facilities.
b. Pre-training competence levels in certain skills can be determined on individual trainees.	
c. Practical manipulative skills can be practiced and evaluated.	
d. Instructor time and effort can be utilized more effectively with group training in manipulative skills.	
e. Part-task devices can be tied into central system to provide complex problems.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Classrooms

2. CHARACTERISTIC'S SPECIFICATION: Lect and individual training device capability

CAPABILITIES	LIMITATIONS
f. Classroom demonstration can be more effectively utilized using part-task training devices.	
g. Certain training objectives can be accomplished by use of part-task devices as opposed to full bridge simulator.	

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Computer facility

1. CHARACTERISTIC'S SPECIFICATION: External facility

CAPABILITIES	LIMITATIONS
a. Computer layout and utilization of ancillary equipment not degraded by space requirement of other facilities.	a. Housekeeping facilities (i.e., power, plumbing, heating, etc.) must be separately provided.
b. Updating and/or replacement of equipment will not physically disrupt parent training device.	b. External signal and power transmission lines may be extensive and may be subject to internal damage (i.e., flood, mechanical, fire, etc.).
c. If shared with other activities, costs can be prorated in accordance with usage.	c. If time is shared with another facility, full utilization of training simulator may be degraded.

2. CHARACTERISTIC'S SPECIFICATION: Dedicated, internal facility

CAPABILITIES	LIMITATIONS
a. Housekeeping facilities can be shared with other activities on site.	a. Computer layout and equipment utilization may be degraded by space requirements of other facilities.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Computer facility

2. CHARACTERISTIC'S SPECIFICATION: Dedicated, internal facility

CAPABILITIES	LIMITATIONS
b. Short internal signal and power transmission lines provide less opportunity for external damage (i.e., flooding, fire, etc).	b. Updating and/or replacement of equipment may physically disrupt training simulator.
c. Dedicated use of computer provides full training simulator utilization.	c. Total costs for computer services must be borne by training simulator facility.

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ready/orientation room

1. CHARACTERISTIC'S SPECIFICATION: Share usage with other facilities

CAPABILITIES	LIMITATIONS
a. Shared usage results in more efficient total space allocation.	a. Trainees may be required to share space with administrative functions.
	b. No discussion or debriefing area available without disrupting other functions (i.e., classroom training, office work, etc.).
	c. Trainees may have no area to rest between exercise sessions.
	d. No area available for undisturbed group discussions or individual study.

2. CHARACTERISTIC'S SPECIFICATION: Dedicated space

CAPABILITIES	LIMITATIONS
a. Shipboard decor can be used to enhance pre-exercise atomosphere.	a. Dedicated area may degrade space requirements of other facilities.
b. Area can be used for briefing/debriefing in an informal, relaxed atomosphere.	
c. Space can be utilized for uninterrupted group discussions and individual study.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ready/orientation room

2. CHARACTERISTIC'S SPECIFICATION: Dedicated space

CAPABILITIES	LIMITATIONS
d. Area can be located in close proximity to training device to provide realism in bridge watchstanding routine during lenthy scenarios.	
e. Most suitable when night adaption is required.	
f. Facility isolation provides increased security if required.	

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Maintenance shop

1. CHARACTERISTIC'S SPECIFICATION: Replacement/minor repair

CAPABILITIES	LIMITATIONS
a. Quick module replacement or troubleshooting capability exists.	a. Major component repair not accommodated.
b. Alternate use of components may be used to bypass inoperative components and maintain machine uptime.	b. Lengthy downtime may result from off-site repair of components.
c. Limited space required, providing additional area for other facilities.	c. Due to off-site repair requirements, larger number of spare components must be available to minimize downtime.
d. Capital investment in sophisticated diagnostic and repair equipment not required.	d. Component repair may be delayed due to workload in nondedicated repair facility.
e. Preventive maintenance can be performed in accordance with established procedures.	e. Nondedicated facility may be geographically distant necessitating long transit times for components.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

G. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Maintenance shop

2. CHARACTERISTIC'S SPECIFICATION: Major component repair

CAPABILITIES	LIMITATIONS
a. Diagnosis and repair of complicated components can be accomplished.	a. Area required may degrade space requirements for other facilities.
b. Replacement of repaired components not affected by transit time from off-site repair facility.	b. Capital investment and maintenance costs of sophisticated diagnostic and repair equipment may be significant.
c. On-site repair diminishes requirement for spare components.	
d. Workload of facility is dedicated to training simulator. No competition with outside work exists.	

H. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Office spaces

1. CHARACTERISITC'S SPECIFICATION: Outside facility

a. Administrative functions can be carried out with minimal disruption from operational requirements.	a. Administrative services to training simulator may be limited by geographic displacement of office.
b. Dedicated space can be larger since space will not be degraded to provide for other simulator facilities.	b. Housekeeping facilities must be separately provided.

2. CHARACTERISTICS'S SPECIFICATION: Internal facility

a. Close proximity to training simulator staff and trainees optimizes ability to provide administrative support.	a. Depending on arrangement, disruption by operation staff and/or trainee may occur to an unacceptable degree.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

IX. SUBSYSTEM: Facility Arrangement

H. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Office spaces

2. CHARACTERISTIC'S SPECIFICATION: Internal facility

CAPABILITIES	LIMITATIONS
b. Housekeeping services of parent facility can be utilized.	b. Space to be utilized for administrative purposes may be constrained by other facility requirements.
c. Simulator is readily accessible for trainee remedial work.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

X. SUBSYSTEM: Own Ship Characteristics and Dynamics

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Equations of motion

1. CHARACTERISTIC'S SPECIFICATION: Low fidelity

CAPABILITIES

a. Sophistication of physical installation at a minimal level.

b. Program inputs are simple with few parameters.

c. Manual steering can be represented.

d. Simple single rudder configurations in one location are represented.

e. Propeller configurations limited as to number and type.

f. Standard or most representative propeller hydrodynamic characteristics are represented.

g. Rudder, propeller and hull form parameters are injected as individual inputs.

h. Propeller direction can be represented in the forward or reverse directions.

i. General ship types (i.e., cargo, LNG, tanker can be represented).

j. Ship system casualties imposed manually by instructor.

k. Environmental effects can be represented by one set/drift factor injected by instructor.

LIMITATIONS

a. Autopilot representation not required.

b. Loading configuration limited to extremes (i.e., fully ballasted vs. fully loaded.

c. Multiple ship control casualities limited by available instructor time and simulators capability.

d. Restricted water effects (i.e., shallow depth, bank effects, etc) cannot be represented.

e. Simulator motion in response to environmental factors is not physically represented.

f. Instantaneous ship control response degrades realism in resultant ship action.

g. Scenarios must be constrained to reflect the physical limitations of the installation.

h. Realism of scenarios is constrained by ship action/reaction.

i. Segmented exercises may have to be stopped/restarted to change parameters thus degrading continuity.

j. Simplicity of scenarios makes determination of trainee input levels difficult.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

X. SUBSYSTEM: Own Ship Characteristics and Dynamics

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Equations of motion

1. CHARACTERISTIC'S SPECIFICATION: Low fidelity

CAPABILITIES	LIMITATIONS
l. Magnitude and direction of external factors imposed from specific quadrants within specific magnitude limits: (1) Wind (2) Current (3) Waves	k. Manual inputs of parameters limited by available instructor time.
m. Effect of environmental factors can be depicted visually as yaw and pitch.	l. Trainees constrained to certain levels of training imposed by lack of scenario flexibility.
n. Indicators and controls operate independently, dependent on instructor input of proper values.	m. Certain degree of negative training results from lack of realism in ship model action/reaction.
o. System malfunctions can be utilized to train for taking corrective action to minimize casualty effect.	n. Lack of simulator realism inhibits transfer of training to "real world".
p. Simple scenarios can be constructed to provide adequate training in a variety of situations.	o. Lack of variety of training situations inhibits training in "special situations" not available in "real world".
q. Instructor control of exercise accomplished by manual input of parameters.	
r. Levels of training available in graduated steps.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

X. SUBSYSTEM: Own Ship Characteristics and Dynamics

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Equations of motion

2. CHARACTERISTIC'S SPECIFICATION: High fidelity

CAPABILITIES	LIMITATIONS
a. Autopilot and manual steering can be represented.	a. Mathematical models are complex with many variables encompassing multiple magnitude factors.
b. Steering capability of multiple rudder types and variable rudder placement can be incorporated.	b. High fidelity outputs may require additional instructor/operator personnel.
c. Variable propeller configurations (i.e., number of propellers, number of blades, pitch, etc.) can be utilized.	c. A higher level of training of operating/instructor personnel may be required.
d. Variable propeller hydrodynamic characteristics can be integrated.	d. Capacity of physical plant to monitor/control exercise requires high degree of sophistication.
e. Interaction between propeller, rudder and hull form can be integrated.	e. Requires a complete mathematic model of ship hydrodynamics, ship systems, environmental effects and waterway parameters for classes of ships represented.
f. Variable aspects of propeller direction can be utilized (i.e., forward, reverse, twisting, etc).	
g. Effect of various conditions of loading on steering, propulsion hull form and external factors can be integrated.	
h. Multiple ship types can be represented.	
i. Combined effects of single or multiple steering, propulsion or electric power casualties can be integrated.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

X. SUBSYSTEM: Own Ship Characteristics and Dynamics

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Equations of motion

2. CHARACTERISTIC'S SPECIFICATION: High fidelity

CAPABILITIES	LIMITATIONS
j. Combined effect of restricted waters on steering and propulsion capability can be integrated.	
k. Combined effect of environmental factors (i.e., wind, current, waves) on ship motion (pitch, roll and yaw) can be realistically portrayed either physically or visually.	
l. Magnitude and relative direction of external factors can be made infinitely variable within specified limits. (1) Wind (2) Current (3) Waves	
m. Ship control response time can be varied to realistically depict response time for varied ship types and methods of control (i.e., autopilot vs. manual, direct speed control vs. engine order telegraph).	
n. Indicator and control interactions can be modified to reflect delayed response times and imposed casualties.	
o. Systems malfunctions can be utilized to train in the use of alternate systems and/or correct reaction to ship control casualty situation.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

X. SUBSYSTEM: Own Ship Characteristics and Dynamics

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Equations of motion

2. CHARACTERISTIC'S SPECIFICATION: High fidelity

CAPABILITIES	LIMITATIONS
p. Scenarios can reflect the maximum amount of flexibility, variability, complexity and realism.	
q. Transition between segments of continuing exercise can be made smoothly and without interruption. (i.e., changes in weather, operating areas, etc.).	
r. Flexibility of scenarios permits diagnostic exercises structured to determine trainee individual input levels.	
s. Instructor control of exercise is maximized.	
t. Flexibility in level of training to suit trainee requirements is maximized.	
u. Training transference to "real world" is maximized due to simulator realisms.	
v. Device flexibility provides training situations unobtainable in "real world" because of restraints imposed by safety, geography, available ship types and/or available time.	

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Steering Response

1. CHARACTERISTIC'S SPECIFICATION: Instantaneous

CAPABILITIES	LIMITATIONS
a. Depending on installation, instructor/operator may inject delay by manual controls.	a. Shiphandling exercises suffer from lack of realism.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

X. SUBSYSTEM: Own Ship Characteristics and Dynamics

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Steering response

1. CHARACTERISTIC'S SPECIFICATION: Instantaneous

CAPABILITIES	LIMITATIONS
b. Computer capacity may be devoted to othe. functions.	b. Lack of realism may affect ability of experienced trainees to make judgemental decisions.
	c. Lack of realistic ship motion may require longer simulator familiarization time for experienced trainee.
	d. Lack of variable reaction time gives all classes of ships equal response characteristics.
	e. Manual injection of delay by instructor increases overall instructor workload.
	f. Certain training objectives cannot be conducted under accurate conditions for a given class of vessel.

2. CHARACTERISTIC'S SPECIFICATION: Automatic time delay

CAPABILITIES	LIMITATIONS
a. Shiphandling exercises can reflect handling characterisitcs of different classes of vessels.	a. Computer capacity for other functions may be diminished.
b. Experienced trainee can adjust to simulator response with minimum of familiarization time.	
c. Trainee judgmental decisions will be based on realistic maneuver parameters.	
d. Automatic insertion of delay frees instructor/operator for other functions.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

X. SUBSYSTEM: Own Ship Characteristics and Dynamics

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Steering response

2. CHARACTERISTIC'S SPECIFICATION: Automatic time delay

CAPABILITIES	LIMITATIONS
e. Certain training objectives can be conducted under accurate conditions for a given class of vessel.	

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Propulsion response

1. CHARACTERISTIC'S SPECIFICATION: Instantaneous

CAPABILITIES	LIMITATIONS
a. Depending on installation, instructor/operator may delay by use of manual control.	a. Shiphandling exercises suffer from lack of realism.
b. Computer capacity is available for other functions.	b. Lack of realism may affect ability of experienced trainees to make judgemental decisions.
	c. Lack of realistic ship motion may require longer simulator familiarization time for experienced trainee.
	d. Lack of variable reaction time gives all classes of ships equal response characteristics.
	e. Manual injection of delay by instructor increases overall instructor workload.
	f. Ship acceleration/deceleration will not conform to curves for specific classes of vessels.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

X. SUBSYSTEM: Own Ship Characterisitcs and Dynamics

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Propulsion response

2. CHARACTERISTIC'S SPECIFICATION: Automatic time delay

CAPABILITIES	LIMITATIONS
a. Shiphandling exercises can reflect handling characteristics of different classes of vessels.	a. Computer capacity for other functions may be diminished.
b. Experienced trainee can adjust to simulator response with minimum of familiarization time.	
c. Trainee judgmental decisions will be based on realistic maneuver parameters.	
d. Automatic insertion of delay frees instructor/operator for other functions.	
e. Certain training objectives can be conducted under accurate conditions for a given class of vessel.	
f. Ship acceleration/deceleration may be programmed to conform to curves for specific classes of vessels.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS

XI. SUBSYSTEM: Own Ship Malfunction System

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: *Steering*

1. CHARACTERISTIC'S SPECIFICATION: No malfunction imposed

CAPABILITIES	LIMITATIONS
a. Instructor can provide on/off capability.	a. Training in use and recognition of capability of alternate steering methods cannot be accommodated.
b. Training in use of engines for steering possible considering rudder at 0^{o}.	
c. Instructor not required to devote time to impose casualty and observe resultant response.	
d. Lack of casualty input requirements provides additional capacity for other own ship motion equation parameters.	

2. CHARACTERISTIC'S SPECIFICATION: Mechanical malfunction imposed

CAPABILITIES	LIMITATIONS
a. Rudder casualty situations can be represented in varying degrees of severity.	a. Alternate steering system parameters require additional inputs to own ship motion equation.
b. Training in use of engines, anchor and tugs in steering casualty situations can be accommodated.	b. Instructor required to devote time to impose casualty and observe resultant response.
c. Training in use and capability of alternate steering methods can be accommodated.	
d. Steering malfunctions can be integrated with other casualty situations to increase level of training and/or to evaluate level of input characteristics of prospective trainee.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XI. SUBSYSTEM: Own Ship Malfunction System

A. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Steering

2. CHARACTERISTIC'S SPECIFICATION: Mechanical malfunction imposed

CAPABILITIES	LIMITATIONS
e. Complexity of any scenario can be substantially enhanced by imposition of steering casualties.	

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Propulsion

1. CHARACTERISTIC'S SPECIFICATION: No malfunction imposed

CAPABILITIES	LIMITATIONS
a. Instructor can impose on/off capability.	a. On/off casualty does not reflect other casualty situations which may occur in "real world".
b. On two shaft vessel instructor may impose on/off casualty on one or both shafts independently.	b. No windmill or drag effect possible.
	c. On two shaft vessels, may not be able to simulate loss of "Forward Only," "Reverse Only," or twisting capability.
	d. Training in recognition of control vs. indication failures cannot be accommodated.

2. CHARACTERISTIC'S SPECIFICATION: Mechanical malfunction imposed

CAPABILITIES	LIMITATIONS
a. Training in recognition, identification and correction of various propulsion indication and control casualties can be accommodated.	
b. Selective use of casualty can be integrated with other system casualties to increase level of training and/or to evaluate level of input characteristics of prospective trainee.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XI. SUBSYSTEM: Own Ship Malfunction System

B. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Propulsion

2. CHARACTERISTIC'S SPECIFICATION: Mechanical malfunction imposed

CAPABILITIES	LIMITATIONS
c. Flexibility and difficulty of scenarios can be increased by use of propulsion control/indication casualties.	
d. Hydrodynamic "windmill and drag" effect can be incorporated in ship control scenarios.	

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Electric power

1. CHARACTERISTIC'S SPECIFICATION: No malfunction imposed

CAPABILITIES	LIMITATIONS
a. Scenarios can be constructed to provide maximum training levels with ship systems fully operational.	a. Selected ship systems cannot be shut down to provide additional flexibility and complexity to a variety of scenarios.
b. Complexity of input/output computer characteristics is less than that required for representing malfunctions.	b. Training realism and trainee response to casualty situations cannot be maximized.
c. Instructor is not required to devote time to impose casualty and observe resultant response.	

2. CHARACTERISTIC'S SPECIFICATION: Electrical malfunction imposed

CAPABILITIES	LIMITATIONS
a. Flexibility and complexity of a variety of scenarios can be upgraded by the imposition of this casualty on numerous own ship subsystems.	a. Instructor is required to devote time to impose casualty and observe resultant response.
b. Training realism and trainee response to casualty situations can be maximized.	b. Malfunction may cause steering/propulsion control/indication failures which may require additional inputs/outputs to own ship motion equation.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XI. SUBSYSTEM: Own Ship Malfunction System

C. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Electric power

2. CHARACTERISTIC'S SPECIFICATION: Electrical malfunction imposed

CAPABILITIES	LIMITATIONS
c. Primary training objectives can be shifted/ injected in mid-exercise by imposition of casualties.	

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Radar/CAS

1. CHARACTERISTIC'S SPECIFICATION: No malfunction/degradation imposed

CAPABILITIES	LIMITATIONS
a. Wide variety of navigation/collision avoidance/shiphandling exercises can be developed under optimum display conditions.	a. Lack of environmental degradation provides unrealistic representation of system capabilities and limitations.
b. Display data is consistent, accurate and results in "pure" solutions.	b. Exercise environmental effects not correlated with radar picture (i.e., rain squalls, sea return).
c. Instructor not required to devote time to impose degradation/malfunction and monitor resultant action.	

2. CHARACTERISTIC'S SPECIFICATION: Malfunction/degradation imposed

CAPABILITIES	LIMITATIONS
a. Imposition of signal degradation/system casualty provides realistic appreciation of system capabilities and limitations.	a. Instructor required to devote time to impose degradation/malfunction and monitor resultant response.
b. Complexity of scenarios can be upgraded by use of degradation/malfunction situations.	b. Raw data received from displays is not "pure" and may degrade certain basic scenarios and/or training objectives.
c. Raw data received from displays require interpretation thereby increasing the training opportunity in any given scenario.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XI. SUBSYSTEM: Own Ship Malfunction System

D. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Radar/CAS

2. CHARACTERISTIC'S SPECIFICATION: Malfunction/degradation imposed

CAPABILITIES	LIMITATIONS
d. Environmental effects can be injected to correlate with visual scene.	
e. Training response to casualty/degradation situation can be maximized.	

E. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ship control indicators

1. CHARACTERISTIC'S SPECIFICATION: No malfunctions imposed

CAPABILITIES	LIMITATIONS
a. Concurrent failure of indicator system with control system failure can be represented.	a. Indicator system malfunction can only occur in conjunction with control system malfunction.
b. Instructor has capability to control exercise complexity by imposition of entire control/indicator system casualty.	b. Instructor does not have capability to control exercise by selective indicator casualties.
c. Most scenarios can be utilized without this casualty capability.	c. Shiphandling and collision avoidance scenarios cannot reflect maximum flexibility unless ship control system failures are instituted.

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ship control indicators

2. CHARACTERISTIC'S SPECIFICATION: Malfunctions imposed

CAPABILITIES	LIMITATIONS
a. Indicator system malfunction can be differentiated from control system malfunction.	
b. Trainee can be cued for loss of indication, only, as opposed to control system failure.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XI. SUBSYSTEM: Own Ship Malfunction System

F. ALTERNATIVE SUBSYSTEM CHARACTERISTIC: Ship control indicators

2. CHARACTERISTIC'S SPECIFICATION: Malfunctions imposed

CAPABILITIES	LIMITATIONS
c. Training in ship control operation with loss of specific indicators can be accommodated.	
d. Training in the use of alternate methods of indication (i.e., mechanical vs. electrical) can be accommodated.	
e. Instructor can control complexity of exercise by use of selected indicator casualties.	
f. Loss of gyro indication can provide shiphandling training by observation of ship head only.	

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS

XII. SUBSYSTEM: Training Assistance Technology

NOTE: The Training Acceptance Technology subsystem addresses training techniques and methodology as opposed to the hardware capabilities presented in previous sections. The table below differs in context from that of the other subsystems in that only accrued benefits are delineated. Omission of any of these subsystem characteristics would have a corresponding detrimental effect on the training capability of the training simulator and its assigned personnel.

A. SUBSYSTEM CHARACTERISTIC: Data recording

1. Instructor input
2. Automatic input
3. Recall capability

CAPABILITIES AND/OR BENEFITS

1. Instructor recording work load decrease permits increased flexibility and variety of instructor participation in parameter inputs and complex training techniques.
2. Availability of recorded data permits increased accuracy of rerun/replay of exercise.
3. Recorded data points provide ability to utilize "fast" time to bypass unwanted exercise segments during rerun/replay.
4. Exercises can be segmented at specific data points to facilitate use of varied training techniques.
5. Wide flexibility in the use of varied training techniques is possible.
6. Data recording permits the establishment of individual and team performance standards.
7. With the establishment of performance standards, individual performance measurements are attainable.
8. Scenario complexity, flexibility, variety and realism is maximized.
9. The scope of the training objectives is increased by the ability to record data.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XII. SUBSYSTEM: Training Assistance Technology

A. SUBSYSTEM CHARACTERISTIC: Data recording

CAPABILITIES AND/OR BENEFITS

10. Permanence of recorded data permits use of post-problem critique training technique which diminishes requirement for exercise "freezes".

11. Diminished number of exercise "freeze" points contributes greatly in preserving continuity of program segments in long exercises.

12. The ability to compile performance measurement data enhances the ability to delineate specific training objectives for given levels of trainee input characteristics.

13. Based on recorded performance measurements, diagnostic scenarios can be structured to determine trainee input characteristics.

14. Compilation of recorded data can provide the ability to build viable historical files for reference/research purposes.

15. Variety of recording methods provides a more comprehensive data base for output information.

B. SUBSYSTEM CHARACTERISTIC: Data reduction

1. Screening/evaluation
2. Summary of relevant data
   a. printout
   b. CRT display
   c. tape
      (1) audio
      (2) video
   d. storage ability
   e. recall capability

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XII. SUBSYSTEM: Training Assistance Technology

B. SUBSYSTEM CHARACTERISTIC: Data reduction

CAPABILITIES AND/OR BENEFITS

1. Training techniques can be structured on the basis of filtered and evaluated data as opposed to masses of "raw" data.
2. Flexibility, realism, variety and complexity of exercises can be of the highest order due to availability of valid information for replay accuracy.
3. Permanency of screened data can be assured for later use.
4. Summarization of critical action/reaction can be utilized for demonstration and/or post-problem critique purposes.
5. Immediate recall for positive guidance and immediate repetition training techniques is available.
6. Filtered data is available to establish performance standards and individual performance measurements.
7. The scope of training objectives can be enlarged on the basis of validity of recall data.
8. Validity and permanence of output data permits use of post-problem critique training technique which diminishes requirement for exercise "freezes".
9. Exercise continuity is enhanced in long exercises by item 8.
10. Comprehensive data base provides more input for evaluation with corresponding increase in output validity.
11. Filtered/summarized output data and valid performance measurements enhance ability to delineate specific training objectives for given levels of trainee input characteristics.
12. Summarized output data is available for storage to compile historical files for reference/research purposes.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XII. SUBSYSTEM: Training Assistance Technology

C. SUBSYSTEM CHARACTERISTIC: Observation/monitoring

1. Remote vs direct observation
2. Input/output interface
3. Behavioral vs procedural evaluation
4. Problem display (access)

CAPABILITIES AND/OR BENEFITS

1. Automatic monitoring of trainee action/response decreases instructor work load.
2. Decreased workload permits instructor to utilize immediate feedback techniques.
3. Flexibility of instructor to utilize other training techniques is enhanced.
4. Rerun/replay is made more effective for post-problem critique.
5. Performance standards can include subjective evaluations of trainee.
6. Effectiveness of diagnostic scenarios increased by ability to obtain qualitative personal observations by the instructor.
7. Observation/monitoring outputs may be integrated with hard data outputs for more complete trainee evaluation.
8. Casualty control training particularly requires behavioral observation of trainee.
9. Simultaneous observation of trainee and exercise parameters from remote station enhances ability to critique exercise.
10. Performance measurements can include both subjective and objective parameters.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XII. SUBSYSTEM: Training Assistance Technology

C. SUBSYSTEM CHARACTERISTIC: Observation/monitoring

CAPABILITIES AND/OR BENEFITS

11. Increased data base for performance measurement increases validity of compiled results for historical files.

12. Training technique flexibility permits judicious use of exercise techniques of freeze, restart and rerun.

13. Scope of training objectives can be increased.

D. SUBSYSTEM CHARACTERISTIC: Performance measurement

1. Provide standards
2. Individual performance levels
3. Structured scenarios
4. Diagnostic exercises

CAPABILITIES AND/OR BENEFITS

1. Performance standards can be developed from historical performance of individual trainees over a given time period.

2. Individual trainee performance measurement can be compared with previously set standards.

3. Standards can be arbitrarily adjusted to reflect trainee previous experience/training.

4. Validity of comparative performance measurements can be assured by utilizing the same standards for trainees of comparable training/experience.

5. Scenarios can be structured to provide maximum effectiveness for a variety of training objectives.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XII. SUBSYSTEM: Training Assistance Technology

D. SUBSYSTEM CHARACTERISTIC: Performance measurement

CAPABILITIES AND/OR BENEFITS

6. Results of diagnostic exercises can determine reliably the level of trainee input characteristics.

7. Instructor can perform evaluations of trainees based on a firm set of values rather than intuitive judgments.

8. As a result of valid performance evaluations, instructors can utilize the proper training technique to provide maximum training results.

E. SUBSYSTEM CHARACTERISTIC: Diagnostic feedback/demonstration

1. Graphics
   a. CRT
   b. printout
2. Data display
   a. ship tracks
   b. tables/graphs
3. Real time
   a. delayed
   b. pre-exercised
4. Alternative Action

CAPABILITIES AND/OR BENEFITS

1. Availability of diagnostic exercises provides capability to assess trainee level of input characteristics.

2. Pre-exercise demonstration exercises can provide opportunity to delineate knowledge requirements and training objectives (i.e., transition training from moderate/large size ships to very large (VLCC) ships)

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XII. SUBSYSTEM: Training Assistance Technology

E. SUBSYSTEM CHARACTERISTIC: Diagnostic feedback/demonstration

CAPABILITIES AND/OR BENEFITS

3. Diagnostic exercises can be utilized to determine flexibility and complexity of training scenarios to be selected.
4. Scenarios can be structured to provide the required flexibility/complexity.
5. The variety of training techniques utilized can be enhanced by the inclusion of these subsystem characteristics.
6. Use of real time vs fast time can allow instructor to become time efficient without degrading training efficiency.
7. Demonstration exercises can be utilized to provide alternative courses of action in compare/contrast and post-problem critique training methods.
8. Replay of exercise for performance feedback or experience enhancement can be under same parameters as initial exercise.

F. SUBSYSTEM CHARACTERISTIC: Problem control

1. Freeze, restart, replay
2. Fast time
3. Project ahead
4. Target control
5. Environmental control
6. Scenario selection/training objective

CAPABILITIES AND/OR BENEFITS

1. Wide variety of training techniques can be utilized.
2. Economical use of time can be realized by using "fast" time to isolate certain exercise segments.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XII. SUBSYSTEM: Training Assistance Technology

F. SUBSYSTEM CHARACTERISTIC: Problem control

CAPABILITIES AND/OR BENEFITS

3. Use of "fast" time can speed up uninteresting or not required exercise segments to concentrate on segments which illustrate specific training objectives.

4. Consequences of varied alternative actions can be evaluated by projecting exercise ahead for demonstration purposes (i.e., Trial Maneuver in Collision Avoidance Scenarios).

5. Instructor enjoys flexibility in exercise control methods in order to take advantage of developing situations not envisioned in original scenario.

6. Instructor can impose initial control of exercise by scenario selection to carry out specific training objectives.

7. Instructor control of exercise parameters (i.e., environment, ship contact) can modify or increase exercise difficulty as desired.

8. Maximum scenario flexibility complexity, realism and variety are available to the instructor.

9. Flexibility of exercise will provide detailed data to enhance validity of performance measurements.

10. Complexity of specific exercise segments can be increased by speeding up required decision/response times.

11. Retrieval of stored data can be speeded up for critique purposes.

12. Variable start/restart points within the scenario permits use of performance feedback or positive guidance training techniques at any time during the exercise.

13. Sequencing of exercise segments can be emphasized by using freeze capability.

TABLE E-3-1. SIMULATOR CAPABILITIES AND LIMITATIONS (CONT'D)

XII. SUBSYSTEM: Training Assistance Technology

G. SUBSYSTEM CHARACTERISTIC: Long term storage library

1. Scenarios
2. Statistical performance records
3. Scenarios vs training objectives
4. Exercise areas

CAPABILITIES AND/OR BENEFITS

1. If desired, historical file can be maintained to provide:

   a. Individual scenario effectiveness as evidenced by trainee performance measurements.
   b. Scenarios structured to provide varied levels of training.
   c. Trainee performance records as individuals and/or as a statistical profile.

2. Flexibility will be provided for selection of scenarios to fulfill certain training objectives.

3. Records will be available for performance comparisons of personnel returning for training at more advanced levels.

4. Individual performance records could be available to determine license eligibility.

5. Information would be available for new instructor familiarization and/or training.

EXHIBIT E-4

CHARACTERISTIC ALTERNATIVE EFFECTIVENESS RATINGS

CHARACTERISTIC ALTERNATIVE EFFECTIVENESS RATINGS

TABLE E-4-1 is a sample of a relative effectiveness rating system for the characteristic alternatives of the visual image display subsystem.

A scale of effectiveness values from 0 (low) to 5 (high) was developed to realistically assess the relative capabilities of the alternative characteristics to improve and demonstrate the skills contained in the SFOs. The scale of values is:

0 - The characteristic alternative cannot contribute to the training of the SFO in any way. Training must be achieved by other means if possible.

1 - A few of the SFO skills can be trained by the characteristic alternative. Most of the remaining skills can be trained by other means.

2 - A moderate number of the SFO skills can be trained by the characteristic alternative. Most of the remaining skills can be trained by other means.

3 - Most of the SFO skills can be trained by the characteristic alternative. Supplementary use of other characteristics can complete the training of the SFO.

4 - The SFO can be trained by the characteristic alternative but not to the ultimate degree. Supplementary use of other characteristics may be required.

5 - a. The entire SFO can be trained by the characteristic alternatives equally well, or

b. The SFO can be trained by the specific characteristic alternatives to the maximum extent. Some integration with other characteristics may be required.

A weighting system for each SFO was determined by considering the impact on ship and/or crew safety. All classroom and nonapplicable SFOs were eliminated.

The SFOs were categorized as follows:

Category 1 - LOW

Ship readiness
Ship characteristics
Routine duties
Administration and/or organization

Category 2 - MEDIUM

Routine maneuvering
Routine navigation

Internal casualty control (fire, flooding)
Routine ship traffic tracking and evaluating
Shiphandling in docking, mooring, and anchoring situations

Category 3 - HIGH

External casualty control response (i.e., man overboard)
Maneuvering under adverse conditions
Navigating under adverse conditions
Rules of the Road/collision avoidance
Operation of CAS under extreme conditions
Material failures

The SFO weighting categories were applied to the individual effectiveness values to achieve an overall effectiveness coefficent. The method used to determine this coefficient is shown below.

$$\frac{(V_1 \times W_1) + (V_2 \times W_2) \ldots + (V_n \times W_n)}{N} = E$$

where:

V = individual effectiveness value
W = SFO category
N = number of applicable SFOs
E = overall effectiveness coefficient

The overall effectiveness coefficient was divided by the number of applicable SFOs to obtain an average effectiveness coefficient for each alternative within the visual image display subsystem (see TABLE E-4-2). (Note: the estimated cost factor shown in the table is discussed in Exhibit E-5.) With respect to overall and average effectiveness coefficients, only alternatives within a given subsystem characteristic should be compared. The coefficients do not reflect comparisons between different characteristics (e.g., color versus field of view).

TABLES E-4-1 and E-4-2 present the effectiveness values and coefficients for subsystem I (visual image display). For the remaining subsystems, effectiveness values are not presented, although the data is available. Effectiveness and cost coefficients for subsystems II through VIII, X, and XI are given in TABLES E-4-3 through E-4-11. Subsystems IX and XII were not numerically evaluated.

As can be seen in TABLES E-4-2 through E-4-11, some subsystem characteristics did not lend themselves to specific alternatives other than "present/not present". Values were assigned to indicate their relative contribution to the possible completion of the training objective. Combined use of these characteristics (e.g., CRT plotter and chart table) could increase the training simulator capability substantially over and above that provided by use of one or another of the characteristic alternatives. These items have been marked with an asterisk.

The values used in the tables have been assigned subjectively. However, personnel with human factors training and active licensed deck officers have examined this data and indicated agreement with both the method of computation and the validity of the results.

TABLE E-4-1. EFFECTIVENESS VALUES FOR VISUAL IMAGE DISPLAY SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristics / SFO	I. Fundamental Shiphandling	A. Ship/Environmental Effect	1.	B. Ship Characteristic	1.	2.	3.	4.	5.	C. Hydrodynamic Effect	1.	2.	D. Maneuver Techniques	1.	2.	3.	4.	5.	E. Rules of the Road	1.	2.	3.	II. Integrated Shiphandling	A. Port Entry	1.	2.	3.	4.	5.
A. Color																													
1. Black & White			3			3	3	3	3		3	3		3	3	5	3	3		3	3	3			3				3
2. Multi-Color			4			4	4	4	4		4	4		4	4	5	4	4		4	4	5			5				5
B. Day/Night																													
1. Night Only			3			2	3	3	2		2	2		2	2	2	3	3		4	4	5			4				4
2. Day Only			4			5	4	4	5		3	3		5	5	5	4	4		4	4	5			4				4
3. Day & Night			4			5	4	4	5		4	4		5	5	5	4	4		5	5	5			5				5
C. Horizontal Field of View																													
1. ±60° FM Bow			2			3	3	2	2		1	1		1	1	0	1	1		0	0	5			2				1
2. ±90° FM Bow			3			3	3	3	3		3	3		1	1	5	3	4		2	5	5			3				3
3. ±120° FM Bow			4			4	4	4	4		4	4		2	2	5	4	4		3	5	5			4	N	N	N	4
4. 360°			4			5	5	5	5		5	5		4	4	5	5	4		5	5	5			5	O	O	O	5
D. Vertical Field of View					C																					T	T	T	
1. Eye Level to +10°			2		L	2	5	5	2		2	2		3	3	1	2	2		5	5	5			4				4
2. ±10°			3		A	3	5	5	3		3	3		4	4	2	3	3		5	5	5			5	A	A	A	5
3. >+10°			4		S	4	5	5	4		4	4		4	4	5	4	4		5	5	5			5	P	P	P	5
E. Own Ship Motion					S																					P	P	P	
1. One Axis			0		R	0	0	0	0		0	0		0	0	0	0	0		0	0	0				L	L	L	0
2. Two Axes & Rotation			5		O	4	4	4	4		4	4		4	4	4	4	4		4	4	4			4	I	I	I	4
3. Three Axes & Rotation			5		O	5	5	5	5		5	5		5	5	5	5	4		4	4	4			4	C	C	C	4
F. Contact Motion					M																					A	A	A	
1. Stationary			5			N	5	5	5		5	5		5	5	5	5	5		0	0	0			5	B	B	B	5
2. One Axis			5			A	5	5	5		5	5		5	5	5	5	5		0	0	0			5	L	L	L	5
3. Two Axes			5				5	5	5		5	5		5	5	5	5	5		5	5	5			5	E	E	E	5
4. Rotation			5				5	5	5		5	5		5	5	5	5	5		5	5	5			5				5

TABLE E-4-1. EFFECTIVENESS VALUES FOR VISUAL IMAGE DISPLAY SUBSYSTEM CHARACTERISTIC ALTERNATIVES (CONT'D)

Alternative Characteristics	6.	7.	8.	9.	10.	11.	12.	13.	14.	II. Restricted Waterway	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
A. Color																													
1. Black & White		3	3					5	3		3	4	4	3	3	3	3	3	3	3	3	5	3	3	2			4	4
2. Multi-Color		5	5					5	5		4	4	4	4	4	4	4	4	4	4	4	5	4	4	4			4	4
B. Day/Night																													
1. Night Only		4	4					5	3		2	3	3	2	2	2	2	2	2	4	4	5	3	3	3			4	4
2. Day Only		4	4					5	4		3	3	4	3	3	3	3	3	3	4	4	5	3	3	3			4	4
3. Day & Night		5	5					5	5		4	4	4	4	4	4	4	4	4	5	5	5	4	5	4			4	5
C. Horizontal Field of View																													
1. $+60^\circ$ FM Bow		1	2					5	2		2	3	5	2	2	4	4	2	3	1	1	1	1	1	5			4	7
2. $+90^\circ$ FM Bow		3	3					5	3		3	3	5	3	5	4	4	3	3	3	3	3	2	3	5			4	2
3. $+120^\circ$ FM Bow	N	4	4	N	N	N	N	5	4		4	4	5	4	5	4	4	4	4	4	4	4	3	4	5	N	N	4	3
4. 360°	O	5	5	O	O	O	O	5	5		5	5	5	5	5	4	4	5	5	5	5	5	4	5	5	O	O	4	5
D. Vertical Field of View	T			T	T	T	T																			T	T		
1. Eye Level to $+10^\circ$		4	4					5	4		2	4	5	2	2	2	2	2	2	2	2	2	2	2	2			4	2
2. $+10^\circ$	A	5	5	A	A	A	A	5	5		3	5	5	3	3	3	3	3	3	4	4	3	3	3	4	A	A	4	4
3. $>+10^\circ$	P	5	5	P	P	P	P	5	5		4	5	5	4	4	4	4	4	4	5	5	4	4	4	5	P	P	4	4
E. Own Ship Motion	P			P	P	P	P																			P	P		
1. One Axis	L	0	0	L	L	L	L	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	L	L	0	0
2. Two Axes & Rotation	I	4	4	I	I	I	I	3	5		5	5	5	5	5	5	5	5	4	4	4	5	5	5	4	I	I	4	4
3. Three Axes & Rotation	C	4	4	C	C	C	C	5	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	C	C	5	5
F. Contact Motion	A			A	A	A	A																			A	A		
1. Stationary	B	5	0	B	B	B	B	0	0		5	5	5	2	2	2	2	0	5	5	5	5	5	5	5	B	B	0	0
2. One Axis	L	5	0	L	L	L	L	0	0		5	5	5	2	2	2	2	0	5	5	5	5	5	5	5	L	L	0	0
3. Two Axes	E	5	5	E	E	E	E	5	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	E	E	5	5
4. Rotation		5	5					5	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5			5	5

TABLE E-4-1. EFFECTIVENESS VALUES FOR
VISUAL IMAGE DISPLAY SUBSYSTEM CHARACTERISTIC ALTERNATIVES (CONT'D)

Alternative Characteristics	C. Single Pt. Mooring	1.	2.	D. Docs Approach	1.	2.	E. Anchoring Approach	1.	2.	3.	III. Emergencies	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	IV. Team Coordinator	1.	2.	V. Bridge Procedures	1.	2.
A. Color																												
1. Black & White		4	4		3	3			4	4			4	4	4	3	3	3	3	3	3	3						3
2. Multi-Color		4	4		4	4			5	5			5	5	5	5	5	5	5	5	5	5						5
B. Day/Night																												
1. Night Only		4	4		3	3			4	4			3	3	3	3	3	3	5	4	3	3						4
2. Day Only		4	4		4	4			4	4			4	4	4	4	4	4	4	4	4	4						4
3. Day & Night		5	5		4	4			5	5			5	5	5	5	5	5	5	5	4	4						5
C. Horizontal Field of View																												
1. $\pm 60^{\circ}$ FM Bow		1	1		0	0			1	1			2	2	2	2	3	3	5	5	0	1						1
2. $\pm 90^{\circ}$ FM Bow		2	2		2	2		C	2	2		C	3	3	3	3	3	3	5	5	0	3						2
3. $\pm 120^{\circ}$ FM Bow		4	4		4	4		L	3	2		L	4	4	4	4	4	4	5	5	2	4		N	N			3
4. 360°		5	5		5	5		A	4	4		A	5	5	5	5	5	5	5	5	5	5		O	O			5
D. Vertical Field of View								S				S												T	T		C	
1. Eye Level to $+10^{\circ}$		2	2		0	0		S	3	3		S	2	2	2	2	2	2	5	2	0	2					L	2
2. $\pm 10^{\circ}$		4	4		2	2		R	4	4		R	3	3	3	3	3	3	5	3	2	3		A	A		A	5
3. $>\pm 10^{\circ}$		4	5		5	5		O	5	5		O	4	4	4	4	5	4	5	4	5	4		P	P		S	5
E. Own Ship Motion								O				O												P	P		S	
1. One Axis		0	0		0	0		M	0	0		M	0	0	0	0	0	0	0	0	0	0		L	L		R	0
2. Two Axes & Rotation		4	4		5	5			4	4			5	5	5	5	5	5	5	5	4	4		I	I		O	5
3. Three Axes & Rotation		5	5		5	5			5	5			5	5	5	5	5	5	5	5	5	5		C	C		O	5
F. Contact Motion																								A	A		M	
1. Stationary		0	0		0	0			0	0			5	0	0	0	0	0	0	1	0	0		B	B			2
2. One Axis		0	0		0	0			0	0			5	2	2	2	2	2	2	2	2	2		L	L			3
3. Two Axes		5	5		5	5			5	5			5	5	5	5	5	5	5	5	5	5		E	E			5
4. Rotation		5	5		5	5			5	5			5	5	5	5	5	5	5	5	5	5						5

TABLE E-4-1. EFFECTIVENESS VALUES FOR
VISUAL IMAGE DISPLAY SUBSYSTEM CHARACTERISTIC ALTERNATIVES (CONT'D)

Alternative Characteristics / SFO	I. Fundamental Shiphandling — A. Ship/Environmental Effect 1.	B. Ship Characteristic 1.	B. 2.	B. 3.	B. 4.	B. 5.	C. Hydrodynamic Effect 1.	C. 2.	D. Maneuver Techniques 1.	D. 2.	D. 3.	D. 4.	D. 5.	E. Rules of the Road 1.	E. 2.	E. 3.	II. Integrated Shiphandling — A. Port Entry 1.	A. 2.	A. 3.	A. 4.	A. 5.
G. Contact Control																					
1. Fixed Track	5	C		5	5	5	5	5	5	5	0	5	5	5	5	5	5	N	N	N	5
2. Pre-Programmed	5	L		5	5	5	5	5	5	5	0	5	5	5	5	5	5	O	O	O	5
3. Flexible Cont.	5	A		5	5	5	5	5	5	5	5	5	5	5	5	5	5	T	T	T	5
H. Resolution		S																			
1. <10' of Arc	4	S	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	A	A	A	5
2. 10'-20' of Arc	3	R	4	4	4	4	3	3	4	4	3	3	3	5	5	5	4	P	P	P	4
3. >20' of Arc	2	O	4	4	4	4	2	2	4	4	2	2	2	5	5	5	3	P	P	P	3
I. Luminance		O																L	L	L	
1. <5 Ft-L's	3	M	5	4	4	5	3	3	5	5	3	3	3	4	4	5	4	I	I	I	4
2. 5-10 Ft-L's	3		5	4	4	5	4	4	5	5	4	4	4	5	5	5	5	C	C	C	5
3. 10-20 Ft-L's	4		5	4	4	5	5	5	5	5	5	4	4	5	5	5	5	A	A	A	5
4. Over 20 Ft-L's	3		3	3	3	3	3	3	3	3	3	3	3	3	3	5	3	B	B	B	3
J. Contrast Ratio																		L	L	L	
1. <25%	3		5	5	5	5	2	2	5	5	3	3	3	3	3	3	3	E	E	E	3
2. 25% to 50%	3		5	5	5	5	3	3	5	5	3	3	3	4	4	4	4				4
3. 50% to 75%	4		5	5	5	5	4	4	5	5	4	4	4	4	4	4	4				4
4. >75%	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5				5
K. Type Exercise Area																					
1. Open Sea	0		5	5	5	5	0	0	5	5	5	0	0	5	5	5	0				0
2. Coastal Waters	5		5	5	5	5	0	0	5	5	4	0	0	5	5	5	5				5
3. Harbor Waters	5		5	5	5	0	5	5	0	0	0	5	5	5	5	5	0				0
L. Size Gaming Area																					
1. 25 Sq. Miles or less	5		5	5	5	5	4	4	4	4	5	5	5	4	4	4	4				4
2. 25 to 625 Sq. Miles	4		4	4	4	4	5	5	5	5	4	4	4	5	5	5	5				5
3. >625 Sq. Miles	1		1	1	1	3	2	2	3	3	0	1	1	3	3	3	3				3
SFO WEIGHT	3		1	1	1	1	2	2	1	1	3	3	3	3	3	3	3				3

TABLE E-4-1. EFFECTIVENESS VALUES FOR VISUAL IMAGE DISPLAY SUBSYSTEM CHARACTERISTIC ALTERNATIVES (CONT'D)

Alternative Characteristics	6.	7.	8.	9.	10.	11.	12.	13.	14.	B. Restricted Waterway	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
G. Contact Control																													
1. Fixed Track		5	5'					0	5		5	5	5	4	4	4	4	3	5	5	5	5	5	5	5			0	0
2. *Pre-Programmed*	N	5	5	N	N	N	N	0	5		5	5	5	4	4	4	4	4	5	5	5	5	5	5	5	N	N	4	4
3. Flexible Cont.	O	5	5	O	O	O	O	5	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	O	O	5	5
H. Resolution	T			T	T	T	T																			T	T		
1. <10' of Arc		5	5					5	5		4	4	4	4	4	4	5	4	4	4	4	4	4	4	4			4	4
2. 10'-20' of Arc	A	4	4	A	A	A	A	5	4		4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	A	A	3	3
3. >20' of Arc	P	3	3	P	P	P	P	5	3		2	4	4	3	3	2	3	3	2	2	2	2	2	2	2	P	P	2	2
I. Luminance	P			P	P	P	P																			P	P		
1. <5 Ft-L's	L	4	4	L	L	L	L	4	4		4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	L	L	3	3
2. 5-10 Ft-L's	I	5	5	I	I	I	I	5	5		5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	I	I	4	4
3. 10-20 Ft-L's	C	5	5	C	C	C	C	5	5		5	5	5	5	5	5	5	4	5	4	4	5	5	5	5	C	C	5	5
4. Over 20 Ft-L's	A	3	3	A	A	A	A	3	3		3	3	3	3	3	3	4	3	3	5	5	3	3	3	3	A	A	3	3
J. Contrast Ratio	B			B	B	B	B																			B	B		
1. <25%	L	3	3	L	L	L	L	3	3		3	3	3	3	3	3	3	3	3	2	2	2	3	3	3	L	L	3	2
2. 25% to 50%	E	4	4	E	E	E	E	4	4		4	4	4	3	3	4	4	4	3	3	3	3	3	3	3	E	E	3	3
3. 50% to 75%		4	4					4	4		4	4	4	4	4	5	5	4	4	4	4	4	4	4	4			4	4
4. >75%		5	5					5	5		5	5	5	5	5	5	5	4	4	5	5	5	5	5	4			4	5
K. Type Exercise Area																													
1. Open Sea		0	0					0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0	0
2. Coastal Waters		5	5					5	5		0	0	0	0	0	0	0	0	5	5	5	0	0	0	5			5	5
3. Harbor Waters		0	0					0	0		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5			5	5
L. Size Gaming Area																													
1. 25 Sq. Miles or less		5	5					5	5		4	5	5	4	4	5	5	4	5	5	5	4	4	4	4			4	4
2. 25 to 625 Sq. Miles		5	5					5	5		5	4	4	5	5	4	4	5	4	4	4	5	5	5	5			5	5
3. >625 Sq. Miles		5	3					3	3		2	1	1	2	2	1	1	2	1	1	1	2	2	2	2			2	2
SFO WEIGHT		2	2					2	2		3	3	3	2	2	3	3	3	3	3	2	3	3	3	2			2	2

TABLE E-4-1. EFFECTIVENESS VALUES FOR VISUAL IMAGE DISPLAY SUBSYSTEM CHARACTERISTIC ALTERNATIVES (CONT'D)

Alternative Characteristics	C. Single Pt. Mooring	1.	2.	D. Dock Approach	1.	2.	E. Anchoring Approach	1.	2.	3.	III. Emergencies	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	IV. Team Coordinator	1.	2.	V. Bridge Procedures	1.	2.
G. Contact Control																												
1. Fixed Track		0	0		0	0			0	0			5	5	5	5	0	5	5	3	0	5						5
2. Pre-Programmed		5	5		0	0			0	0			5	5	5	5	0	5	5	4	0	5						5
3. Flexible Cont.		5	5		5	5			5	5			5	5	5	5	5	5	5	5	5	5						5
H. Resolution																												
1. <10' of Arc		5	5		5	5		C	5	5		C	4	4	4	4	5	5	4	4	5	4		N	N		C	5
2. 10'-20' of Arc		3	3		5	5		L	3	3		L	3	3	3	3	4	3	4	3	5	3		O	O		L	4
3. >20' of Arc		2	2		5	5		A	2	2		A	2	2	2	2	3	2	4	2	5	2		T	T		A	3
I. Luminance								S				S															S	
1. <5 Ft-L's		3	3		5	5		S	5	5		S	3	3	3	3	5	3	3	3	4	4		A	A		S	4
2. 5-10 Ft-L's		4	4		5	5		R	5	5		R	4	4	4	4	5	4	4	4	4	4		P	P		R	5
3. 10-20 Ft-L's		4	4		5	5		O	5	5		O	4	4	4	4	5	4	4	4	4	4		P	P		O	5
4. Over 20 Ft-L's		3	3		3	3		O	3	3		O	3	3	3	3	3	3	3	3	3	3		L	L		O	3
J. Contrast Ratio								M				M												I	I		M	
1. <25%		2	2		3	3			3	3			3	3	3	3	3	3	3	3	4	5		C	C			2
2. 25% to 50%		3	3		3	3			3	3			3	3	3	4	4	4	4	4	4	5		A	A			3
3. 50% to 75%		4	4		4	4			4	4			4	4	4	4	4	4	4	4	4	5		B	B			4
4. >75%		5	5		5	5			5	5			5	5	5	5	5	5	5	5	5	5		L	L			5
K. Type Exercise Area																								E	E			
1. Open Sea		0	0		0	0			0	0			0	0	0	0	0	5	5	5	0	0						5
2. Coastal Waters		5	5		0	0			5	5			0	0	0	0	0	5	5	5	5	0						5
3. Harbor Waters		5	5		5	5			5	5			5	5	5	5	5	5	5	5	5	5						5
L. Size Gaming Area																												
1. 25 Sq. Miles or less		4	4		5	5			5	5			5	5	5	5	5	5	5	5	5	5						5
2. 25 to 625 Sq. Miles		5	5		4	4			4	4			5	5	4	4	4	5	5	4	3	4						4
3. >625 Sq. Miles		2	2		1	1			1	1			1	1	1	1	1	5	5	1	1	1						1
SFO WEIGHT		2	2		2	2			2	2			3	3	3	3	3	3	3	3	2	3						3

TABLE E-4-2. EFFECTIVENESS AND COST COEFFICIENTS
FOR VISUAL IMAGE DISPLAY SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost Factor
A. Color				
1. Black + White	55	458	8.3	1.0
2. Multicolor	55	590	10.7	2 - 3
B. Day/Night				
1. Night only	55	429	7.8	0.4
2. Day only	55	547	9.9	0.9
3. Day + Night	55	609	11.1	1.0
C. Horizontal Field of View				
1. $\pm 60^o$ FM Bow	55	272	4.9	0.4
2. $\pm 90^o$ FM Bow	55	435	7.9	0.6
3. $\pm 120^o$ FM Bow	55	531	9.6	>1.0*
4. 360^o	55	606	11.0	2.0
D. Vertical Field of View				
1. Eye level to $+10^o$	55	326	5.9	0.6
2. $\pm 10^o$	55	525	9.5	1.0
3. Greater than $\pm 10^o$	55	593	10.7	1.0
E. Own Ship Motion				
1. One Axis	55	000	0.0	0.75
2. Two Axes + Rotation	55	597	10.8	1.0
3. Three Axes + Rotation	55	644	11.7	1.3
F. Contact Motion				
1. Stationary	54	378	7.0	0.5
2. One Axis	54	434	8.0	0.8
3. Two Axes	54	660	12.2	0.9
4. Rotation	54	660	12.2	1.0
G. Contact Control				
1. Fixed Track	54	508	9.4	0.5
2. Pre-Programmed	54	550	10.1	0.7
3. Flexible Control	54	660	12.2	1.0

*Function of horizontal field of view

NOTE: Explanation of Estimated Cost Factor found in Exhibit E-5.

TABLE E-4-2. EFFECTIVENESS AND COST COEFFICIENTS
FOR VISUAL IMAGE DISPLAY SUBSYSTEM CHARACTERISTIC ALTERNATIVES (CONT'D)

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost Factor
H. Acuity				
1. Less than 10 min of arc	55	592	10.7	1.0
2. 10-20 min of arc	55	499	9.1	0.5
3. Over 20 min of arc	55	368	6.7	<0.5 ①
I. Luminance				
1. Less than 5 ft-Lamberts	55	484	8.8	0.7
2. 5-10 ft Lamberts	55	586	10.7	1.0
3. 10-20 ft-Lamberts	55	614	11.2	1.5
4. Over 20 ft-Lamberts	55	420	7.6	②
J. Contrast Ratio				
1. Less than 25%	55	398	7.2	0.4
2. 25% to 50%	55	473	8.6	0.6
3. 50% to 75%	55	546	9.9	0.8
4. Over 75%	55	650	11.8	1.0
K. Type Exercise Area				
1. Open Sea	55	150	2.7	.25 ③ .4 ④
2. Coastal Waters	55	347	6.3	.5 .7
3. Harbor Waters	55	570	10.3	1 1
L. Size Exercise Area				⑤
1. 25 sq mi or Less	55	616	11.2	
2. 25 sq mi to 625 sq mi.	55	606	11.0	0.4
3. Greater than 625 sq mi	55	241	4.3	0.6
MAXIMUM	55	665	12.3	1.0

① (Function of Degree)
② Function of display size plus number of projectors
③ Model Board
④ CGI Data Base Cost Only
⑤ Model Board or CGI Data Base

NOTE: Explanation of Estimated Cost Factors found in Exhibit E-5.

TABLE E-4-3. EFFECTIVENESS AND COST COEFFICIENTS
FOR VISUAL IMAGE GENERATION SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost Factor
A. Image Source				
1. Single Bulbs	55	233	4.2	0.2
2. Single Point Sources	55	385	7.0	0.35
3. Model Board/Probe/TV Projector	55	523	9.5	0.6
4. Computer Generated/TV Projector	55	665	12.0	1.0
5. CRT with Infinity Optics	55	449	8.1	1.2
B. Image Reflection				
1. Front Lighted	55	644	11.7	1.0
2. Back Lighted	55	537	9.7	1.2
C. Screen Configuration				
1. Rectangular	55	462	8.4	0.6
2. Curved	55	520	9.4	0.8
3. Cylindrical	55	659	11.9	1.0
D. Projector Control				
1. Pre-Set	55	525	9.5	0.5
2. Computer Controlled	55	598	10.8	1.0
3. Instructor Controlled	55	665	12.0	1.7
MAXIMUM	55	665	12.0	

NOTE: Explanation of Estimated Cost Factor found in Exhibit E-5.

TABLE E-4-4. EFFECTIVENESS AND COST COEFFICIENTS FOR RADAR/COLLISION AVOIDANCE SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost Factor
A. Color				
1. Monochromatic	56	572	10.2	1.0
2. Multi-chromatic	56	665	11.8	1.5
B. Contact Motion				
1. Stationary	56	488	8.7	0.2
2. One Axis (X)	56	517	9.2	0.6
3. Two Axes (X,Y)	56	657	11.7	1.0
C. Bearing Coverage				
1. $\pm 90^{\circ}$ from Bow	56	443	7.9	1.0
2. $\mp 120^{\circ}$ from Bow	56	560	10.0	1.0
3. 360°	56	645	11.5	1.0
D. Range Coverage				
1. 0-5 Miles	56	498	8.8	0.8
2. 0-10 Miles	56	644	11.5	0.9
3. Greater than 10 Miles Only	56	370	6.6	1.0
E. Own Ship's Motion				
1. One Axis	56	10	0.2	0.5
2. Two Axes	56	685	12.2	1.0
F. CRT Resolution				
1. Less than 10 Min of Arc	56	538	9.6	1.6
2. 10-20 Minutes of arc	56	635	11.3	1.0
3. Greater than 20 Min of arc	56	368	6.5	0.8

NOTE: Explanation of Estimated Cost Factor found in Exhibit E-5.

TABLE E-4-4. EFFECTIVENESS AND COST COEFFICIENTS FOR RADAP/COLLISION AVOIDANCE SUBSYSTEM CHARACTERISTIC ALTERNATIVES (CONT'D)

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost Factor
G. CRT Brightness				
1. Less than 20 ft-Lamberts	56	529	9.4	0.8
2. 20-50 ft-Lamberts	56	681	12.1	0.9
3. Over 50 ft-Lamberts	56	410	7.3	1.0
H. CRT Contrast Ratio				
1. Less than 25%	56	139	2.5	0.8
2. 25% to 50%	56	309	5.5	0.85
3. 50% to 75%	56	427	7.6	0.9
4. Over 75%	56	685	12.2	1.0
I. Target Density				
1. 1-5	56	298	5.3	0.9
2. 5-20	56	479	8.5	0.95
3. Over 20	56	667	11.9	1.0
J. Performance Degradation 1. Atmospherics 2. Environmental Interference	These characteristic alternatives tend to degrade the ability of the trainee to complete the SFOs. However, they are included to provide realistic equipment performance and to enhance performance measurement techniques.			Yes No 1 .9
MAXIMUM	56	685	12.2	

NOTE: Explanation of Estimated Cost Factor found in Exhibit E-5.

TABLE E-4-5. EFFECTIVENESS AND COST COEFFICIENTS FOR BRIDGE EQUIPMENT CONFIGURATION SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost Factor +
A. Ship Control				
1. Manual Steering	60	715	11.9	
2. Automatic Steering	60	104	1.7	
3. Indirect Propulsion Control	60	598	10.0	
4. Direct Propulsion Control	60	715	11.9	
*5. Thrusters	60	170	2.8	
B. Anchor Equipment				
1. Remote Control	19	245	12.8	
2. No Control	19	77	4.0	
C. Position Fixing Methods				
*1. Pelorus	60	706	11.7	
*2. Radar	60	662	11.0	
*3. RDF	60	69	1.2	
*4. Loran, Decca, Satellite	60	79	1.3	
5. Doppler Log	60	542	9.0	
6. EM Log	60	365	6.1	
*7. Fathometer	60	656	10.9	
D. Position Plotting Methods				
*1. CRT repeater	60	380	6.3	
*2. Chart Table	60	629	10.4	
*3. Dead Reckoning Tracer	60	635	10.5	
E. Radar/CAS Manual Plotting Station				
*1. CRT Repeater	59	577	9.7	
*2 Chart Table	59	566	9.6	
*3. Dead Reckoning Tracer	59	575	9.7	

+ Detailed component cost information not available at this time.

TABLE E-4-5. EFFECTIVENESS AND COST COEFFICIENTS FOR BRIDGE EQUIPMENT CONFIGURATION SUBSYSTEM CHARACTERISTIC ALTERNATIVES (CONT'D)

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost Factor +
F. Radar/CAS Automatic Plotter				
1. CAS Repeater	59	520	8.8	
G. RADAR/CAS Control and Indication Equipment				
1. Actual Components	59	684	11.5	
2. Simulated Components	59	405	6.9	
H. External Communication Equipment UHF/VHF Radio				
*1. Transceiver Walkie-Talkie	52	532	10.2	
*2. Radio Transceiver Bridge Radio Weather	52	309	5.9	
*3. Facsimile Receiver	52	126	2.4	
I. Interior Communications Equipment				
*1. Sound-Powered Telephone	59	627	10.6	
*2. Electronic Intercom & MC	59	572	9.7	
*3. Dial Telephone	59	287	4.9	
J. Ship System Alarms				
1. Instructor Initiated	57	514	9.0	
2. Programmed or Automatic	57	595	10.4	
K. Situation Alarms				
1. Instructor Initiated	57	512	9.0	
2. Programmed or Automatic	57	595	10.4	
L. Indication Equipment				
1. Actual Components	60	715	11.9	
2. Simulated Components	60	248	4.1	
MAXIMUM	60	715	11.9	

+ Detailed component cost information not available at this time.

TABLE E-4-6. EFFECTIVENESS AND COST COEFFICIENTS FOR AUDIO SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost
A. External Sources				
1. No Auditory Cues	67	221	3.3	0
2. Auditory Cues	67	659	9.8	\$50K to \$100
B. Internal Sources				
1. No Auditory Cues	67	187	2.8	0
2. Auditory Cues	67	690	10.3	\$5,000
MAXIMUM	67	780	11.6	

TABLE E-4-7. EFFECTIVENESS AND COST COEFFICIENTS FOR EXTERNAL FACTORS SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristic	Applicable SOFs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost
A. Visibility				
1. Static or Fixed	67	506	7.6	.75
2. Variable	67	743	11.1	1
B. Set and Drift	67	734	10.9	\$5K to 50\$K ① \$10K ②
C. Sea-State	37	350	9.5	\$50K to \$200K
D. Tugs	25	280	11.2	\$100 to \$200K
MAXIMUM	67	780	11.6	

① Data Base ② Hardware

NOTE: Explanation of Estimated Cost Factor found in Exhibit E-5.

TABLE E-4-8. EFFECTIVENESS AND COST COEFFICIENTS FOR MOTION BASE SUBSYSTEM CHARACTERISTIC ALTERNATIVES

ternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost*
A Stationary	55	336	6.1	---
B. Motion	55	559	10.2	\$300K - \$1M
MAXIMUM	55	610	[illegible].1	

*Hydraulic Motion Platform and Controls

NOTE: Explanation of Estimated Cost Factor found in Exhibit E-5.

TABLE E-4-9. EFFECTIVENESS COEFFICIENTS FOR CONTROL MODE SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$
A. Time Scale			
1. Normal Only	65	494	7.6
2. Fast & Normal	65	600	9.2
B. Start/Restart			
1. Initial Point (T+0)	65	316	4.9
2. Variable Scenario Point (T+?)	65	658	10.1
C. Freeze			
1. Specific Time Points	65	387	6.7
2. Variable Time Points	65	615	9.5
D. Record			
1. Selected Segments	65	437	5.7
2. In Total	65	716	11.0
E. Playback Segmentation			
1. Selected Segments	65	316	4.9
2. In Total	65	692	10.6
F. Playback Time			
1. Normal Only	65	446	6.9
2. Fast & Normal	65	618	9.5
G. Exercise Duration			
1. 0-2 hours	65	618	9.5
2. 2-4 hours	65	507	7.8
3. Over 4 hours	65	350	5.3
MAXIMUM	65	735	11.6

NOTE: Cost factors for these capabilities are inherent in component hardware necessary to provide the capability.

TABLE E-4-10. EFFECTIVENESS COEFFICIENTS FOR
OWN SHIP CHARACTERISTICS AND DYNAMICS SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$
A. Equation of Motion			
1. Low Fidelity	63	235	3.7
2. High Fidelity	63	750	11.9
B. Steering Response			
1. Instantaneous	61	83	1.5
2. Time Delay	61	720	11.8
C. Propulsion Response			
1. Instantaneous	61	85	1.4
2. Time Delay	61	720	11.8
MAXIMUM	61	720	11.8

NOTE: Cost factors are not determinable for these alternatives.

TABLE E-4-11. EFFECTIVENESS AND COST COEFFICIENTS FOR OWN SHIP MALFUNCTION SUBSYSTEM CHARACTERISTIC ALTERNATIVES

Alternative Characteristic	Applicable SFOs (N)	Overall Effectiveness Coefficient (E)	Average Effectiveness Coefficient $(\frac{E}{N})$	Estimated Cost Factor
A. Steering				
1. No Malfunctions	11	3	.3	0.8
2. Malfunctions Imposed	11	160	14.5	1.0
B. Propulsion				
1. No Malfunctions	10	3	.3	0.75
2. Malfunctions Imposed	10	145	14.5	1.0
C. Electric Power				
1. No Malfunctions	9	3	.3	1.0
2. Malfunctions Imposed	9	130	14.4	1.2
D. Radar/CAS				
1. No Malfunctions/Degradation	6	3	.5	0.85
2. Malfunctions/Degradation Imposed	6	85	14.1	1.0
E. Ship Control Indicators				
1. No Malfunctions	10	3	.3	0.9
2. Malfunctions Imposed	10	145	14.5	1.0
MAXIMUM	10	145	14.5	

NOTE: *Explanation of* Estimated Cost Factor found in Exhibit E-5.

EXHIBIT E-5

TRAINING SIMULATOR CHARACTERISTIC COST FACTORS

TRAINING SIMULATOR CHARACTERISTIC COST FACTORS

Exhibit E-5 provides a preliminary method for initial cost evaluation which uses a cost reference base of 1. The estimated cost factor for each subsystem characteristic alternative is shown in TABLES E-4-2 through E-4-8 and E-4-11. (Cost factors for the control mode subsystem and own ship characteristics and dynamics subsystem are not applicable.)

The information in the tables can be used to compare training effectiveness and cost factors to aid the training simulator designer in selecting the required characteristic alternatives in an intelligent and cost effective manner. Zade (1978) states "...the correlation between the exponential increase of cost and the logarithmic increase of fidelity are both related to the training value (of the device). An increment of fidelity has to be paid, the higher and the more advanced the fidelity that is required."

Although many subsystem characteristics are interdependent, the relative cost factors were assigned as if each characteristic being evaluated was independent of the others; i.e., the question of color vs black and white was evaluated without regard to screen configuration, image generation, or target motion capability.

The initial relative costs of hardware capable of producing certain characteristic alternatives were identified. The functional systems approach was used to cut across electrical, electronic, and mechanical hardware systems so that the final cost factor reflects the estimated cost for each functional system characteristic (e.g., visual image display).

Several sources of information were used to develop the estimated cost factors. One source was talking to knowledgeable simulator technical personnel. They were requested to provide cost ratios for various characteristic alternatives rather than absolute dollar estimates since absolute cost data is considered proprietary information. In areas such as auditory and external factors subsystems, absolute dollar values were estimated on a "present/not present" basis. In areas such as bridge equipment configuration and control mode subsystems, the costs hinged on component costs and the "present/not present" condition. No attempt has been made to determine costs for these functional subsystems because of the lack of substantive estimates from technical personnel.

Information presented by various simulator representatives at recent symposiums also provided simulator cost estimates. These figures represent costs incurred in the year the simulator was constructed. Future design and construction must consider possible inflationary pressures.

The resultant costs of training simulators can be defined as:

a. Initial purchase and installation costs

b. Life cycle maintenance costs

c. Life cycle operating costs

d. Component replacement costs

   1. Similar equipment

   2. Advanced state-of-the-art equipm(

e. Add-on capability (capacity)

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The cost data research effort indicates a lack of detailed cost data available on operation and maintenance costs. Therefore, no preliminary cost evaluations have been made in these areas. These estimates will most likely change with time.

The listing below provides a representative sample of relative overall costs for some well-known simulators. The characteristics of these simulators are outlined in Exhibit E-1, so comparative effectiveness cost estimates can be made.

Tepegen Visual Subsystem	$1 million
(1976) Decca Night Simulator	$500,000
(1975) VFW Fokker (film/slides)	$1-1½ million
(1976) CAORF (Eidophor Projectors)	$15 million
(1975) IHI	$2 million

EXHIBIT E-6

TRAINING SIMULATOR SYSTEM DESIGN DEFINITION

TRAINING SIMULATOR SYSTEM DESIGN DEFINITION

This exhibit is a simplified guide for training simulator system design definition. In Appendix A, Exhibits A-5 and A-6, skill and knowledge requirements are listed, and in Exhibit A-8 specific functional objectives are listed. While an individual SFO may provide training and evaluation of several diverse skills, each one is primarily concerned with one major skill; other skills are addressed secondarily. Table E-6-1 addresses only the primary skill involved in each SFO, with the understanding that the (relatively) secondary skills are addressed as primary skills in other SFOs.

Table E-6-1 differentiates between full bridge simulators and part-task trainers. Use of part-task trainers depends on the group being trained, the level of training required, and the stated training objectives determined by that level of training.

Part-task trainers combined with classroom sessions are particularly desirable in a refresher training/fundamental skill training environment. Full bridge simulators are most effective in integrating the skills demonstrated/learned on the part-task trainers. By this philosophy, a training system would utilize supplementary part-task trainers and classrooms to free the full bridge simulator for advanced training and/or certification.

TABLE E-6-1. APPROPRIATE TRAINING SYSTEM ELEMENTS FOR SFO'S

SFO	FULL BRIDGE SIMULATOR	PART TASK TRAINER: RADAR PLOTTING (CAS & NAVIGATION)	PART TASK TRAINER: SHIPHANDLING CHARACTERISTICS	PART TASK TRAINER: DOCKING, MOORING AND ANCHORING	CLASSROOM
I.A.1		X	X		
I.B.1					X
I.B.2	X		X		X
I.B.3			X		X
I.B.4			X		X
I.B.5			X		X
I.C.1	X		X	X	
I.C.2	X		X		
I.D.1			X		
I.D.2			X		
I.D.3	X		X		
I.D.4	X				
I.D.5	X				
I.E.1	X	X			
I.E.2	X	X			
I.E.3	X				
II.A.1	X				X
II.A.2	X				X
II.A.3	X				X *
II.A.4	X				X
II.A.5	X				
II.A.6	X	X			
II.A.7	X				
II.A.8	X	X			
II.A.9	X				

*Classroom fitted with actual navigation training aids with signal inputs.

TABLE E-6-1. APPROPRIATE TRAINING SYSTEM ELEMENTS FOR SFO'S (CONT'D)

SFO	FULL BRIDGE SIMULATOR	PART TASK TRAINER: RADAR PLOTTING (CAS & NAVIGATION)	PART TASK TRAINER: SHIPHANDLING CHARACTERISTICS	PART TASK TRAINER: DOCKING, MOORING AND ANCHORING	CLASSROOM
II.A.10	X				
II.A.11	X				
II.A.12	X				
II.A.13	X				
II.A.14	X				
II.B.1	X		X		
II.B.2	X	X			
II.B.3	X	X			
II.B.4	X	X	X		
II.B.5	X		X		
II.B.6	X	X			
II.B.7	X				
II.B.8	X	X			
II.B.9	X	X			
II.B.10	X				
II.B.11	X	X			
II.B.12	X	X			
II.B.13	X	X			
II.B.14	X	X			
II.B.15	X	X			
II.B.16	X				
II.B.17	X				
II.B.18	X				
II.B.19	X				
II.C.1	X	X		X	
II.C.2	X	X		X	
II.D.1	X	X			
II.D.2	X	X		X	
II.E.1					X
II.E.2	X	X		X	
II.E.3	X	X		X	

TABLE E-6-1. APPROPRIATE TRAINING SYSTEM ELEMENTS FOR SFO'S (CONT'D)

	FULL BRIDGE SIMULATOR	PART TASK TRAINER			CLASSROOM
		RADAR PLOTTING (CAS & NAVIGATION)	SHIPHANDLING CHARACTERISTICS	DOCKING, MOORING AND ANCHORING	
III.1					X
III.2	X	X			
III.3	X	X	X		
III.4	X		X		
III.5	X				
III.6	X			X	
III.7	X				
III.8	X				
III.9	X				
III.10	X			X	
III.11	X				
IV.1	X				
IV.2	X				
V.1					X
V.2	X				

EXHIBIT E-7

REPRESENTATIVE SUBSYSTEM CHARACTERISTIC FIDELITY

REPRESENTATIVE SUBSYSTEM CHARACTERISTIC FIDELITY

Exhibit E-3 sets forth the specific capabilities and limitations of the various subsystem characteristic alternatives. A detailed study of Exhibit E-3 indicates that some characteristics (e.g., target motion in one axis) would not be compatible with the training requirements of a ship maneuvering simulator.

This appendix examines some of the more important training simulator characteristics and compares the state-cf-the-art capability with real world conditions. This comparison and the ultimate selection of the characteristic alternatives will greatly affect the fidelity of the training simulator and therefore its ability to carry out the training objectives. It is emphasized that selection of specific alternatives should be deferred until after the training objectives have been defined. Discussions of these alternatives in this report are based on the training objectives developed during Phase 1.

E.7.1 VISUAL SUBSYSTEMS

It is generally conceded that the most important (and most expensive subsystems embodied in a training simulator) are the visual image generation and display subsystems. It is also apparent that certain training objectives (e.g., radar navigation, radar collision avoidance, electronic navigation, ship casualty control, etc) can be accomplished on p task trainers without the requirement of visual subsystems. However, in a well-rounc training curriculum, these skills are combined with their visual counterparts to provide an integrated skill base capable of handling any given situation the mariner may encounter.

On the basis that the visual subsystems are indeed the most critical factors to be considered in the design and construction of a training simulator, the following representative alternative characteristics are discussed in detail to provide the user with an appreciation of the capability of the state-of-the-art equipment to meet the requirements of the real world:

a. Contrast

b. Luminance (brightness)

c. Resolution

d. Depth perception

e. Target motion

Three characteristics which are closely interrelated and account for most of the quality of a large screen, projected image are contrast, luminance, and resolution. This interrelationship is a direct one in that a decrease in one characteristic has a similar effect on the others if compensatory measures are not employed. FIGURE E-7-1 is a graphic representation of this interrelationship. For discussion purposes each of these characteristics will be examined separately.

E.7.1.1 Contrast. The contrast ratio is the measure of the luminance difference between an object and its background and is usually measured in percent as developed by the formula:

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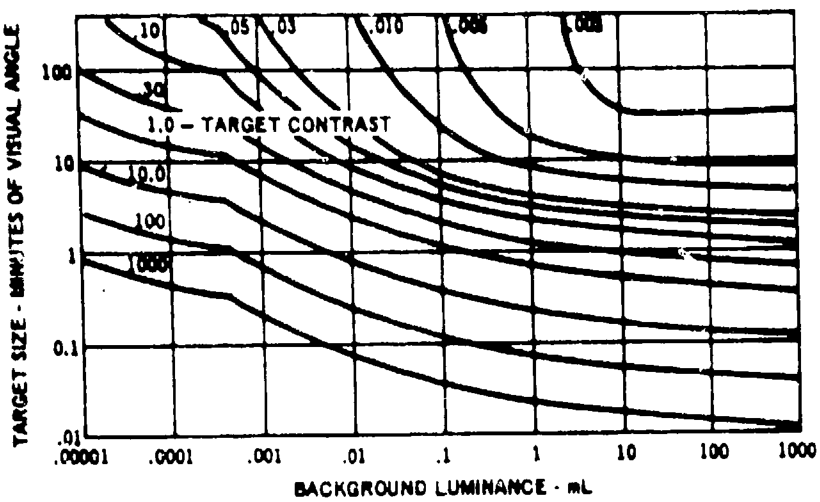

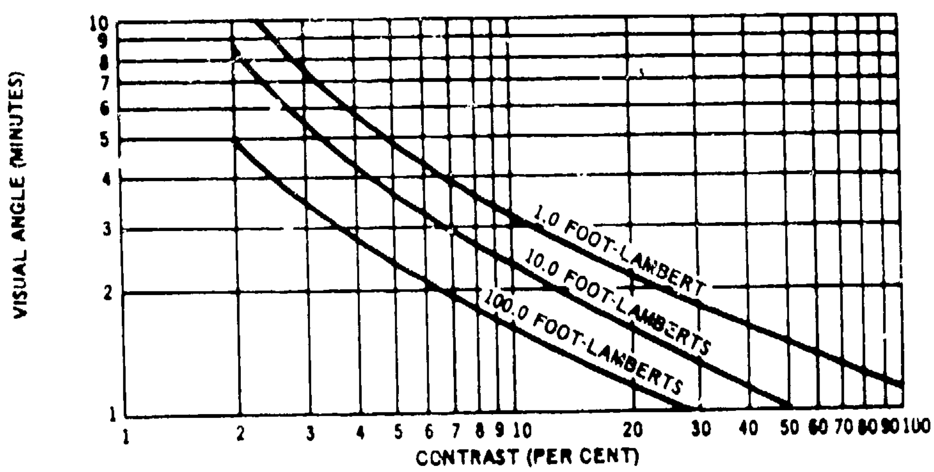

FIGURE E-7-1. LUMINANCE/CONTRAST/RESOLUTION RELATIONSHIP (FROM MEISTER AND SULLIVAN, 1969)

$$\text{Contrast \%} = 100 \times \frac{L_B \;\; L_o}{L_B}$$

where:

L_B = background luminance
L_o = object luminance
(Van Cott and Kinkade, 1972)

From this formula it can be seen that contrast is independent of the luminance value once the contrast ratio has been determined by the image generation system. Decrease in the illumination level in a twilight scenario may decrease the target identification factor in accordance with FIGURE E-7-1; the contrast ratio will remain the same throughout the luminance range.

A contrast ratio of from 75 to 90 percent will provide the optimum contrast under variable luminance conditions (Meister and Sullivan, 1969). Since contrasts in the real world range up to a maximum of 90 percent (Ozkaptan, 1975), it is obvious that the existing training device state-of-the-art capability of greater than 75 percent is more than adequate to meet real world conditions under varying light conditions.

E.7.1.2 Luminance (Brightness). As shown in FIGURE E-7-1, the degree of luminance has a direct relationship on resolution and image identification in large image displays. Farrell and Booth indicate that a luminance factor of 10 ft Lamberts can provide the capability to detect objects with visual angles down to 0.5 minutes of arc. Mil-Std-1472B states that the optimum luminance should be 10 ft Lamberts with acceptable limits of 5-20 ft Lamberts. (See also Van Cott and Kinkade, 1972.) As important as the absolute level of luminance is, it becomes even more important to ensure that there is an even distribution of luminance over the full screen area. Variances in luminance values on screen perimeters may degrade the realism of the visual scene markedly.

As a practical matter, increases in luminance require quantum increases in capital expenditures and maintenance costs for the more sophisticated image display projectors. Screen size and configuration can be utilized to provide luminance values of the required level. Values of from 4 to 16 ft Lamberts may be considered. The smaller the screen size, the brighter the luminance levels obtained from illumination sources of equal intensity.

Ambient illumination must be controlled to permit the use of various designated luminance levels. Stronger ambient lighting may be permitted with back-lighted screens than with front-lighted ones.

FIGURE E-7-2, derived from Corso (1967), presents comparative luminance measurements for real world conditions. These measurements are included so that simulator luminance values may be evaluated on the basis of natural experience.

E.7.1.3 Resolution. Most authorities agree that under normal conditions the human eye has a resolution capability of about 1 minute of arc (Van Cott and Kinkade, 1972 and Ozkaptan, 1975). However, at the present time most existing visual image training simulators have capabilities ranging from 2.96 to 7 minutes of arc.

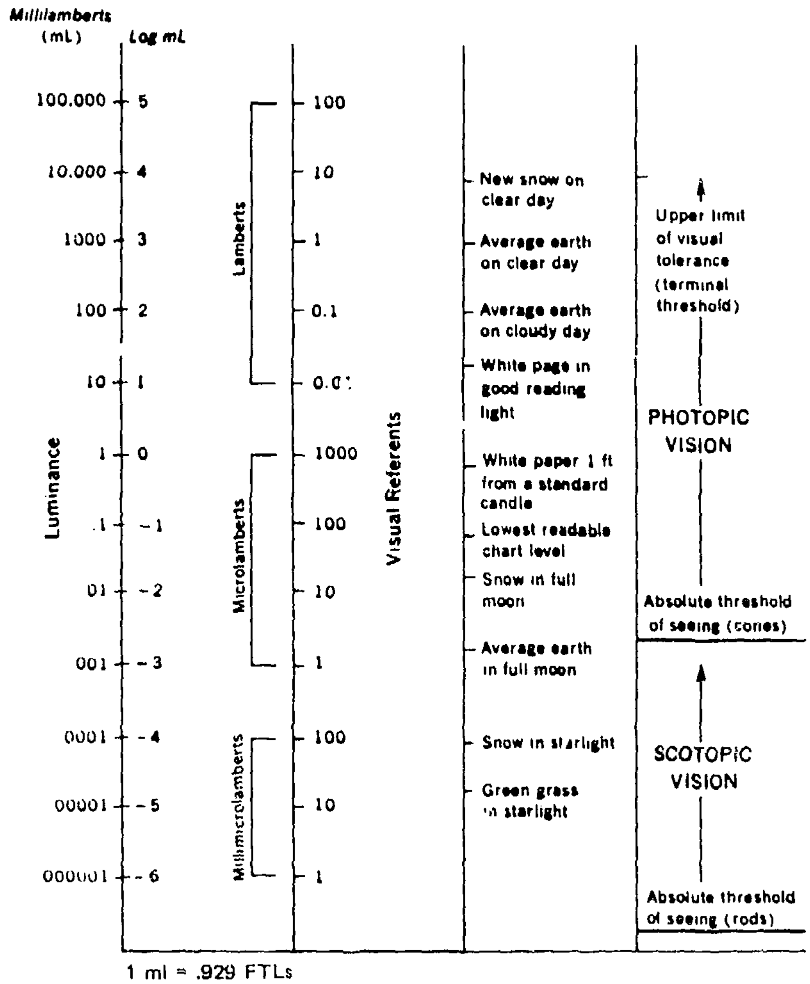

FIGURE E-7-2. RANGE OF EFFECTIVE LIGHT INTENSITIES

Authorities differ in their appreciation of what constitutes optimum resolution for visual large screen displays. Recommendations vary from 1 minute of arc (Van Cott and Kinkade, 1972 and Grapentin, 1978) up to 15 minutes of arc (Mesiter and Sullivan, 1969). These recommendations are tempered by the constraints of cost and training requirements which may be imposed on the training simulator user. The resolution provided by any specific training simulator would, of course, be limited by the method of image generation and projection utilized (see Exhibit E-1).

E.7.1.4 Depth Perception. Depth perception by an observer in the real world is provided by both binocular and monocular cues (Morgan, 1961 and Kaufman, 1974).

Binocular cues are primarily related to the eye itself and are affected by the distance of the image from the observer. In the simulator the distance from the observer to all images is, for all practical purposes, the same; consequently, binocular cues are of no value except as affected by the observer's distance from the screen.

Consequently, depth perception in the simulator must be accomplished by monocular cues generated by the visual subsystems. Some of the cues that can be used to good advantage are:

a. Linear perspective

b. Detail perspective

c. Aerial perspective (haze)

   1. Color differences

   2. Image blurring

   3. Luminance differences

d. Interpositioning and motion parallax

e. Relative size and position in visual field

g. Shadowing and/or texture

These cues are well within the state of the art of most image generation and display systems and can be utilized to a greater or lesser extent dependent on training objectives and scenario content. The degree to which these cues are integrated with one another will have a direct relationship on the realism of the visual scene (Woodworth, 1963).

E.7.1.5 Target Motion. While some existing training simulators limit themselves to stationary targets such as navigation aids, others have the capability to represent two or more ship targets at one time.

Relative target motion can be represented by several methods of image projection and generation. Control of these objects can be accomplished in a variety of ways as delineated in Exhibit E-1.

The maximum angular velocity for detection of an object with detail of 2 minutes of arc is 20 degrees/second (Bartley, 1958 and Hochberg, 1964). In a passing situation, with own ship and target ship making 30 knots at 500 yds distance, the angular velocity is approximately 4 degree/second across the 90-degree line of sight. Angular velocity o target motion in the visual field is therefore limited by the scenario rather than by th viewer or training simulator.

TABLE E-7-1 summarizes values for these representative characteristics.

E.7.2 AUDIO SUBSYSTEM

A second subsystem which can provide a substantial contribution to simulator fidelity is an audio subsystem. Auditory signals can provide cues for identification of, and discrimination between, visual objects: classification of intent of ship contacts; and identification of, and discrimination between, emergency/casualty alarms. In the maritime world the trained ear is subject to many sounds of varying significance. The ability to discriminate and identify these sounds may mean the difference between safe passage and disaster.

The utilization of an audio system to increase the fidelity of a simulator may be based on the auditory factors of frequency, intensity, duration, and direction (McCormick, 1976). Auditory cues are valuable supplements to visual cues and may provide confirming information to the trainee to aid in the decision-making process.

The auditory factors mentioned above can be used in an interrelationship (i.e., frequency and direction) to provide multidimensional coding of the auditory cues. For purposes of discussion, the auditory coding methods have been addressed individually below.

E.7.2.1 Frequency. In the maritime world artificial, external sounds range from low to high frequencies. The frequency depends on the distance the sound must travel to provide the information for which the device was designed. For example, a diaphone or foghorn is designed to provide the maximum range for a navigation hazard. Therefore, since range is the primary consideration in frequency selection for this device, low frequencies ($\approx$500 Hz) are usually selected.

Conversely, if directivity as well as range is required, such as in a bell buoy representation, the frequency selection should be in the medium to high band (1000 to 3000 Hz).

For internal signals and alarms, higher frequencies can be utilized because the distances to the trainee are small. Also, better frequency discrimination at the higher ranges provides a wider variety of discrete frequencies for identification of specific alarms (McCormick, 1976). This frequency coding in conjunction with visual alarm signals can assist the trainee in rapid identification of various alarm/casualty situations.

E.7.2.2 Intensity. This auditory factor can be utilized as a valuable cue to the simulated distance from the sound source. Correlation with frequency bands can be effective in providing realistic identification cues for different types of navigation aids (e.g., distant diaphone versus nearby bell buoy). The intensity of any source, internal or external, must not be strong enough to mask other significant auditory cues.

E.7.2.3 Duration. Duration coding can be an additional auditory cue to identify:

a. Navigation aids
b. Traffic vessel maneuvers
c. Specific internal alarms

TABLE E-7-1. PARAMETERS OF VISUAL CHARACTERISTICS

Characteristic	Limit of Perception	State of the Art Simulator Capability	Acceptable Limits	Maritime Practical Limits	Recommended Simulator Limits
Acuity	1' of arc	3' of arc	1'-3' of arc	1' of arc	1' of arc
Luminance	10^{-4} - 10^{4} ft Lamberts	10^{-5} - 5 ft Lamberts	10^{-5} to a max of 5-20 ft Lamberts	10^{-4} - 10^{4} ft Lamberts	10^{-5} to a max 5-10 ft Lamberts
Contrast	0-90%	0-90%	0-75%	0-90%	0-90%
Angular Motion	Max 60°/sec	0 to 60°/sec*	0-2°/sec	0-4°/sec	0-4°/sec
Depth	0 ft to height of eye horizon	0 ft (mirros, CRT) to height of eye horizon	100 Yds to height of eye horizon	0 ft to height of eye horizon (100' = 11 miles)	

*60°/sec is angular velocity limit at which humans can identify an object

In addition to the interrupted signals, warbling sounds with peaks of fixed duration can also be utilized in identification of internal signals.

E.7.2.4 Direction. Correlation of sound direction with the visual or radar scene will also serve as a confirming or reinforcing cue to the location of specific objects. Discrimination between various navigation aids can be optimized with this technique.

Identification of various internal alarms in the wheelhouse can be further enhanced by placement of the noise source in close proximity to any visual alarm signals. Again, directivity in conjunction with frequency and duration will provide maximum identification cues to the trainee.

TABLE E-7-2, derived from McCormick, 1976, is a representative summary of various auditory cues that may be utilized in a variety of situations.

TABLES E-7-2. CHARACTERISTICS AND FEATURES OF CERTAIN TYPES OF AUDIO ALARMS

Alarm	Intensity	Frequency	Attention-getting ability	Noise-penetration ability
Diaphone (foghorn)	Very high	Very low	Good	Poor in low-frequency noise
Horn	High	Low to high	Good	Good
Whistle	High	Low to high	Good if intermittent	Good if frequency is properly chosen
Siren	High	Low to high	Very good if pitch rises and falls	Very good with rising and falling frequency
Bell	Medium	Medium to high	Good	Good in low-frequency noise
Buzzer	Low to medium	Low to medium	Good	Fair if spectrum is suited to background noise
Chimes and gong	Low to medium	Low to medium	Fair	Fair if spectrum is suited to background noise
Oscillator	Low to high	Medium to high	Good if intermittent	Good if frequency is properly chosen

APPENDIX F

TRAINING SIMULATORS IN OTHER INDUSTRIES

INTRODUCTION

The recent rapid technological advances in the marine industry (including LNG operation, increased operation of ULCC and VLCC tankers and containerships) have been paralleled by an increasing awareness in both the public and private sectors of the risks involved. This focus of attention has led to the realization that training patterns have not altered to reflect and encompass the changes in the maritime community. In contrast, simulators have been extensively used for training in other industries, notably the aviation industry and the nuclear power generation industry, when faced with comparable technological advances.

In 1967 at the SAW international meeting in New York, John Kock exhibited a chart that showed learning proficiency for various stimuli:

<u>LEARNING PROFICIENCY</u>

90% if we can do it
70% if we can say it
50% of what we see and hear
30% of what we see
20% of what we hear
10% of what we read

This chart illustrates that "learning by doing" is the most efficient approach to learning. This philosophy and its application to the airline industry's training requirements, largely through the use of simulators, is significantly responsible for the safe performance record commercial aviators have acquired and maintained with the use of progressively more complex equipment.

This appendix examines the aviation industry's path with respect to training and certification requirements to determine in what ways the marine community can benefit from the knowledge and experience gained by commercial airlines in the development of their training programs to peak efficiency and maximum effectiveness. (See Exhibit F-1.) It also explores the licensing and regulatory requirements for nuclear power plant operators, reviews a sample training program, and studies the usage of simulators in fulfilling training needs. (See Exhibit F-2.)

EXHIBIT F-1

OVERVIEW OF AVIATION INDUSTRY TRAINING

F.1 HISTORY OF AVIATION INDUSTRY TRAINING

F.1.1 Early History

Out of necessity, the aviation industry took the lead in synthetic training for pilots during World War II. Early methods which incorporated the "training by doing" philosophy were proving unacceptable. Losses in training were enormous, and progressive methods had to be examined to determine an alternative approach to flight training that was safer, less costly, and without time constraints.

Rear Admiral Louis De Floriz established the Special Devices Center (later the Naval Training Device Center) within the Office of Naval Research to enhance training through simulation. The first of the devices was the well known Link Trainer -- a moving base, blind-flying trainer. There was just enough apparent advantage, much enthusiasm, and obviously enough financial capability so that each new aircraft acquired by the armed services was supported with a flight simulator for training. Efforts were directed toward developing better computer technology, instrumentation, motion platforms, and representation of the outside world to enable the inclusion of approaches and landings in practice. Concurrently, training psychologists were defining the critical flight skills and developing methods of measuring the extent of learning (transfer of training) and integrating the training into a training curriculum.

The Air Force and Navy conducted studies that demonstrated the savings in time, lives, and dollars through the systematic use of trainers. Nevertheless, there was opposition to the use of simulators. The principles were not being challenged, but the fidelity was. These early simulators lacked suitable motion platforms, visual displays, and in general often did not handle quite like a real aircraft. In spite of these limitations, the simulator had proven its capability as a training aid, and the industry continued its research and development, providing major technological advances which led to the simulator as we know it today (albeit less sophisticated).

At this point in the training progression (late 1950s) approximately 20 to 25 percent of actual flight training was accomplished synthetically. The simulator had the dual purpose of illustrating the material covered in class and the early introduction of proper operational habit patterns to the trainee. Within the next five years, simulator use increased to 50 percent of actual flight training. Ground school, however, was still characterized by large classes using the lecture method with emphasis on how systems operated, but very little on how to operate the system.

Because of this methodology being employed in ground school and the lack of proper training aids at these initial levels, cockpit familiarization and operating procedures were being taught in the simulator. This carryover of ground school into the simulator was an expensive way to introduce trainees to the equipment; and in conjunction with the lack of sophistication in these early simulators, additional hours of flight training were required in a fuel-burning aircraft, thus further increasing the cost. The combined effects of this type of training resulted in a program spanning a period of six to eight weeks and consisting of:

- 15 to 20 days of ground school
- 10 to 12 simulator periods of 4 hours each
- 18 to 20 hours of flight training

F.1.2 Current History

Although a number of improvements were made over the years, the first real breakthrough in approach since the advent of simulation came with the application of specific behavioral objectives to the development of training and certification programs, where the objectives were behavioral (performance expected) as opposed to purely intellectual. This technique ensures that the program adequately addresses all critical performance behaviors and eliminates systems information except for that which is necessary for operation. Previous instruction had placed emphasis upon course content and technique, not on what specific behaviors they intended to incorporate or change in the trainee's repertoire of knowledge and skill.

In implementing this new approach, which required the joint efforts of major air carriers, the Air Force, NASA, educators from leading universities, aircraft manufacturers, and regulatory agencies, the behavioral task analysis emerged as a primary source of data from which to extract specific behavioral objectives. In a task analysis, each procedure required to operate the equipment is identified and further subdivided into major tasks and subtasks to accomplish the required behavioral procedure. The normal action taken to complete each task and the contingency action required if the normal action is not effective are both described. Circumstances which necessitate initiation of procedure are also identified; e.g., the lights, indications, or previous actions which trigger the performance. The systems knowledge that the trainee must possess with respect to the action he takes is made explicit. Systems information is an essential part of the behavioral component and is intended to provide adequate operational understanding of systems concepts. In the behavioral task analysis developed for the aviation industry, rules were developed to guide and control the generation of airplane systems information which crew members had to know, as follows:

a. Systems information should be directly linked to the specific behavior required of the crew member.

b. Systems information related to components (switch, gauge, light, etc) involved with a specified behavior, should provide answers to the following questions:

   - What does it do? (switches and controls)
   - What does it mean? (lights and indicators)
   - Why was this behavior performed?
   - Are there any cautions linked to the behavior?

See FIGURE F-1-1 for a detailed description.

As a basis for analysis, a hypothetical flight was flown. Starting with flight planning and ending with postflight activities, ten flight segments were identified and analyzed in a phase of flight order as follows:

a. Flight planning

b. Preflight

c. Engine start

d. Taxi-out and take-off

e. Climb

f. Cruise

g. Descent approach

h. Final descent and landing

i. Taxi-in and park

j. Postflight

Conditions described as abnormal and emergency were analyzed by aircraft system rather than by phase of flight.

a. Abnormals

- Abnormal air conditioning and pressurization
- Abnormal electrical
- Abnormal fire protection
- Abnormal flight controls
- Abnormal fuel
- Abnormal hydraulic system
- Abnormal landing gear

b. Emergencies

- Loss of all generators
- Loss of all engines
- Engine fire or severe damage
- Rapid depressurization and emergency descent

After the task analysis has been completed, specific behavioral objectives can be extracted which specify:

a. Terminal behavior expected

b. Conditions of that behavior; i.e., limitation or restrictions on trainee while he is performing terminal behavior

c. Trainee characteristics

d. Minimum level of achievement

Once behavioral objectives have been established, such factors as instructional design, approach, and the need for and specification of training aids can be considered. It is important to note that those responsible for preparing course curriculum and materials are given freedom in the selection of format and media for instruction, but they are not given the latitude of including any information which is not detailed in the specific behavioral objectives. Every item considered for inclusion must be measured for its contribution toward enabling the flight officer to meet the behavioral objectives specified.

See FIGURE F-1-2 for an illustration of factors involved in determining new training programs using the systems approach.

KEY

The title of a procedure, group of procedures or checklist.

Identification of crewmember(s) assigned the responsibility for performing this specific step.

A.T.A. chapter name for items involved in performing the step.

The cockpit panel location(s) of the item(s) involved.

6 Space for the future inclusion of Flight Manual and media reference data.

Name of the airline for which the step is applicable.

The latest effectivity date for the step.

The page number of the specific step.

The airplane for which the step is applicable.

A six digit number used to identify a specific step. The first three (3) digits identify the procedure and the last three (3) the number of the step within the procedure e.g., this step is number 120 in the taxi out procedure, 130.

The name of the specific step, checklist or procedure which is to be performed.

The condition(s) for performing the step and contingency conditions.

14 Normal actions, contingency actions and the system information associated with the actions (if required).

15 The conditions which require the performance of the step. When this area is blank, as in this step, it indicates that the condition for performing the step is the completion of the previous step. When other conditions exist they are preceded by a "O." and specified. For example -

O. Captain determines anti-ice is required.

16 The first normal action for the step and is always indicated by "1." Subsequent actions are numbered sequentially.

17 A contingency condition which can occur if action 1 is not completed successfully. If more than one of these conditions can occur, they are successively numbered "1.B., 1.C., 1.D., etc."

18 The actions which must be taken if the contingency condition with the same alphanumeric designation occurs. E.g., Action 1.A is taken only when contingency condition 1.A. occurs.

19 Systems information associated with the specific action just above it. It is always preceded and followed by "$".

20 Any limitations associated with the actions of this step are specified. The "TBD" in this step signifies that there will be a limitation and it is to be determined.

FIGURE F-1-1. SAMPLE OF SYSTEMS INFORMATION SHEET (1 of 2)

BEHAVIORAL COMPONENT

1 PROCEDURE	TAXI OUT	ATA 7
2 CREWMEMBER	CAPTAIN + FIRST OFFICER	FEBRUARY 13, 1970 8
3 ATA SUBJECT	LIGHTING FLIGHT CONTROLS	PAGE 01 9 10 DC-10 130120 11
4 CONTROL LOC.	OVERHEAD PANEL PEDESTAL	
5 FLT. MAN. REF.		
6 MEDIA REF.		

STEP

12 SPOILERS --ARM

13 CONDITIONS 15	14 ACTIONS
	16 1. OBSERVE 'AUTO SPOILER DO NOT USE' LT IS OFF
17 1.A. IF LT IS ON,	18 1.A. NOTIFY PF AND DO NOT ARM AUTO SPOILERS. 19 $ SPOILERS ARE ARMED PRIOR TO TAKE-OFF SO THAT THEY WILL AUTOMATICALLY EXTEND UPON APPLICATION OF REVERSE THRUST FOR A REJECTED TAKE-OFF $
	2. MOVE SPOILER HANDLE TO UP (ARMED) POS AND OBSERVE HANDLE STAYS UP.
2.A. IF HANDLE DOES NOT STAY IN UP POS	2.A. NOTIFY PF AND USE MANUAL SPOILERS FOR R.T.O. (IF REQ'D). $ 'AUTO SPOILER DO NOT USE' LT ON INDICATES A SYS FAILURE. IF THE SYS IS ARMED IT MAY PRODUCE UNWANTED SPOILER OPERATION $

20 LIMITATIONS

LIMITATION TBD

FIGURE F-1-1. SAMPLE OF SYSTEMS INFORMATION SHEET (2 of 2)

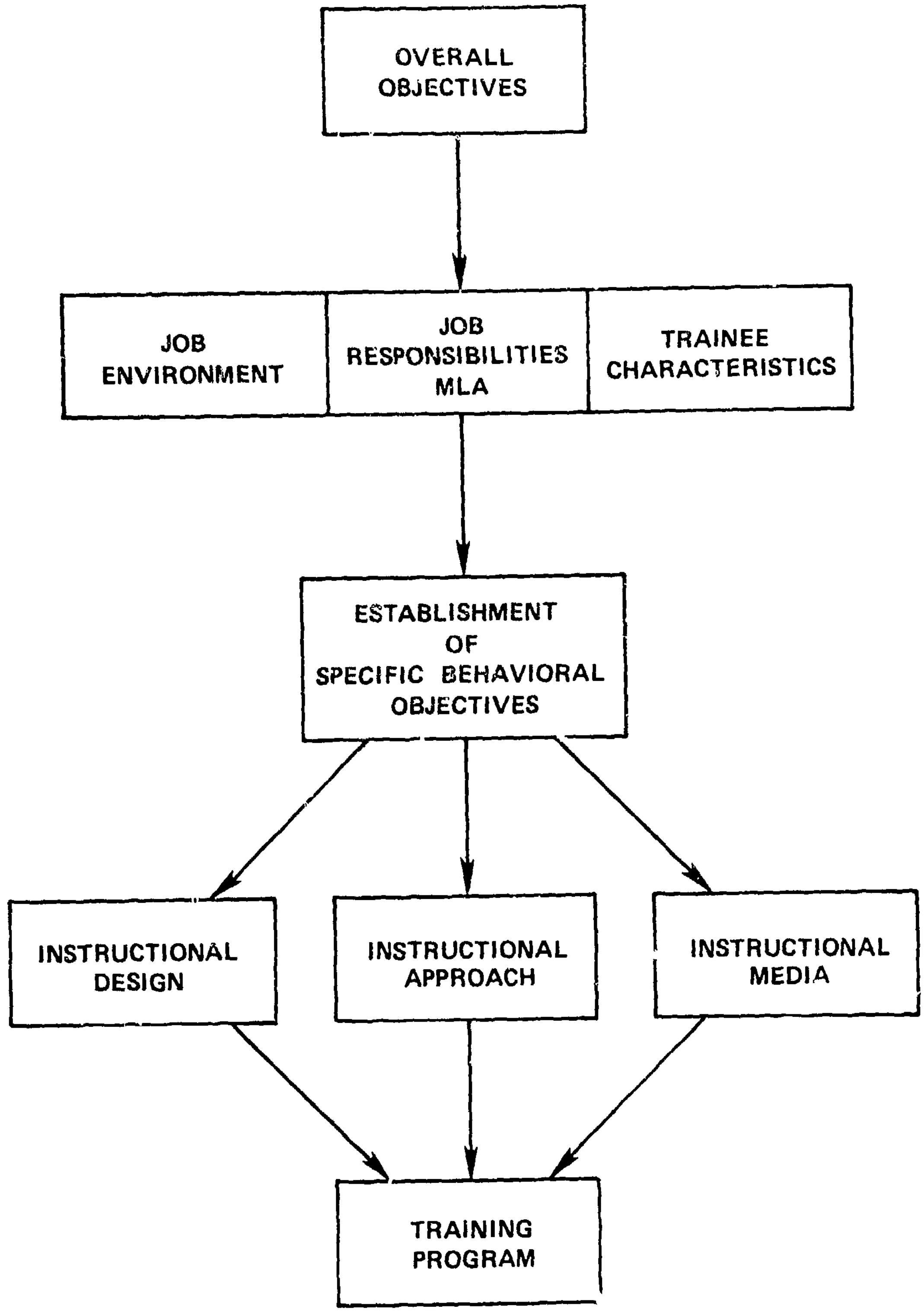

FIGURE F-1-2. FACTORS INFLUENCING NEW TRAINING PROGRAMS — SYSTEMS APPROACH

F.2 EASTERN AIRLINE'S L-1011 TRIM PROGRAM

The application of these concepts may be examined in a typical aviation training program; i.e., Eastern's L-1011 TRIM (Task Related Industrial Methodology) Program. The objectives of the program were to:

a. Enable flight crew members to operate the aircraft in a safe and efficient manner

b. Provide training to FAA oral proficiency at completion of ground school

c. Accomplish the above objectives at minimum cost

To accomplish these objectives, it was evident that changes to their existing programs were necessary. A task analysis was performed and specific behavioral objectives established as described in the previous section. The application of this new methodology resulted in the introduction of a unique training approach capable of accomplishing all course objectives. Elements of the approach are discussed below.

F.2.1 Elements of Approach

Study material was mailed to the trainee in advance of his scheduled school enrollment date. Descriptive overviews of all pertinent systems, presented through programmed instruction booklets, instrument panel drawings, and a list of certain memorization items were included.

Crewmen were examined to determine the depth of their knowledge of the aircraft. This information was used to:

a. Establish homogeneous training groups

b. Determine areas of instruction to be emphasized

c. Measure the extent of learning by comparing this pretest with a posttest, thereby evaluating the effectiveness of the instruction and isolating the areas that required improvement

Multimedia Crew Paced Learning was introduced. This concept included:

a. Crew Training. One instructor is assigned to a team, and depending upon their needs, he can vary combinations of group and individual instruction.

b. Programmed Learning Segments. These were approximately 20 minutes in duration on appropriate media covering description of pertinent controls and indicators, normal, abnormal, and emergency operating procedures for small groups, and individual study.

c. Graded Series of Training Aids, Devices, Simulators, etc. The trainee is given approximately a 2-hour individual session on the audio-visual tape unit or media which the instructor has chosen. He is introduced to the information and procedures and instructed to locate any pertinent controls or indicators on the Cockpit Procedures Mockup. A CPM is a life-size three dimensional photograph of the cockpit located within easy reach of the trainee. The instructor is readily available should the trainee need assistance or further clarification. When he has absorbed this material to his satisfaction, the

student is transferred to the Cockpit Procedures Trainer which is a cockpit including all the systems logic of the simulator except for the flight instrumentation. The trainee will spend approximately 50 percent of his time in the CPT applying concepts learning and/or practicing procedures as a member of the crew. The instructor is on hand to supervise, introduce faults to the system that must be corrected (i.e., equipment malfunctions), and evaluate the crew's performance each period. It is important to note that when considering behavioral objectives using the systems approach with respect to operation, correct completion of the task is the only acceptable criterion for performance. A student must be evaluated continually, building a cumulative record of his abilities. The continuous performance evaluation and immediate feedback provided by the instructor inherent in this approach proved to benefit trainee and company alike.

A necessary adjunct to the most effective use of initial audio-visual tape/CPM/CPT ground training is a step-by-step manual directly corresponding to information being supplied so that a student may further clarify any point which he feels has not been covered to his satisfaction.

d. <u>Paced Instruction</u>. By tutoring and/or assigning more or less individual study, instructors can accelerate or slow down learning so that fast learners are continually challenged and slow learners are kept from being discouraged.

e. <u>Operationally Relevant Tests</u>. Trainees will be examined according to skills and knowledge required to perform a job as outlined in the behavioral objectives, including operational situations, such as possible or probable system malfunctions or performance problems, but not on description/location of components or the like.

FAA orals are taken when the trainee has mastered the material presented in ground school. No minimum time limitation is placed on when the oral can be taken. An average trainee is expected to take the oral examination on the ninth day of training.

In adapting the systems approach to training that only concerns itself with "need-to-know" information, establishing performance criteria was a simple matter. Since all the information and skill development was essential, nothing less than 100 percent learning would be acceptable. This meant that course length must be open-ended. Should the instructor feel that the trainee has not mastered the material, he may repeat all or part of ground school as necessary.

The chart on the following page indicates the schedule for implementing Eastern's L-1011 training program (FIGURE F-1-3).

F.2.2 <u>Advantages</u>

The advantages of this approach are numerous for the crewman, instructor, and company in general.

- The trainee is more able to learn at his own pace, building on his past experience toward well-defined goals (as established by behavioral objectives). Even the simplest of devices in the audio/tape category has inherent systems design incorporating the speed with which the trainee can accept the information being supplied.

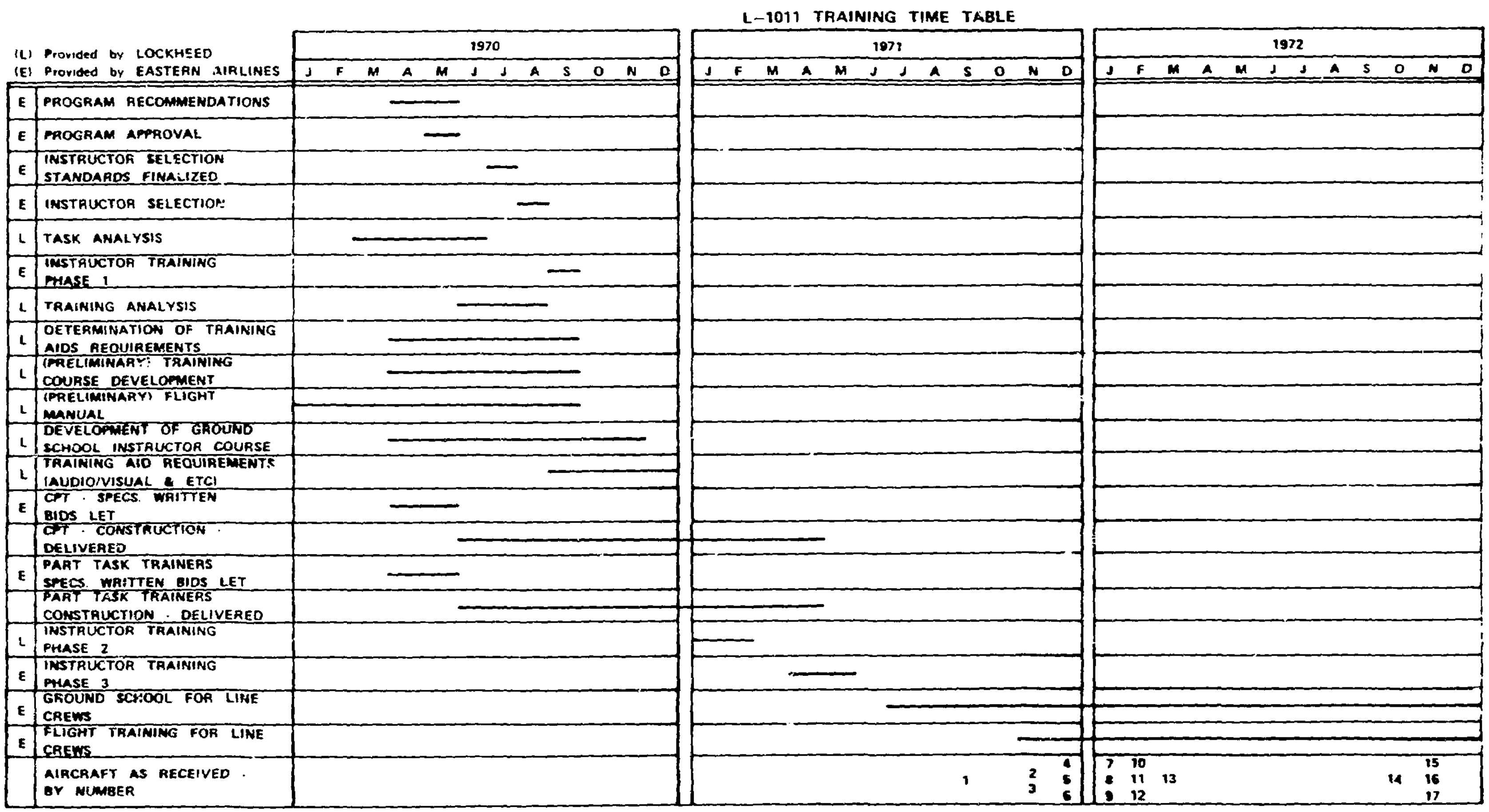

FIGURE F-1-3. SCHEDULE FOR IMPLEMENTING EASTERN'S TRIM PROGRAM

- There is less apprehension than in traditional training programs because course objectives are common knowledge. Therefore, trainees know exactly what they will be tested on. Additional tutoring and self-study material are readily available for those trainees who feel they need further enhancement of study material.

- Trainees go through the program as a crew, interacting and helping one another in many situations, making the training experience more interesting and continually challenging.

- Trainees are continually exposed to required behavior
  - Audio/visual presentation of required behavior
  - Location of pertinent controls on the Cockpit Procedures Mockup
  - Performance of the behavior in the Cockpit Procedures Trainer
  - Observation of fellow crew members performing in the CPT

- Trainees are provided with instant feedback and knowledge of results by the instructor. This method has been proven to enhance retention of study material and learned behaviors.

Trainees will obtain, through interaction, practice, and demonstration of their ability, much greater facility in handling the tasks that they must accomplish in the flight simulator and ultimately the aircraft.

F.2.3 <u>Results</u>

The general pattern of results using this type of instruction is increased effectiveness of training at lower cost. It is obvious that the most cost effective training method makes use of the least sophisticated piece of equipment which will produce the desired results; hence, the development of:

- The Cockpit Procedures Mockup for introduction to procedures
- The Cockpit Procedures Trainer for practice of these procedures
- The simulator for development of technique and maneuvering capabilities
- The aircraft for examination and line operating experience

As a result of the buildup of training, the trainees are better prepared, more familiar with the cockpit, and better drilled on operating procedures prior to flight training. This enables greater emphasis on flight maneuvers and techniques during the simulator phase and has resulted in progressively fewer required maneuvers being performed in the aircraft before a rating is given (see TABLE F-1-1).

This approach has enabled the consolidation of cognitive, psychomotor, and affective behaviors into the development of the knowledge and skills required to complete course objectives, resulting in a program consisting of:

- 8 to 9 days of ground school (1 day of oral examination by FAA after completion)

TABLE F-1-1. MANEUVERS REQUIRED TO BE SATISFACTORILY PERFORMED IN THE AIRPLANE DURING DC-8 CAPTAIN TRANSITION

	2/69	11/70	'74	'77
Prestart and start procedures	X			
Taxiing	X	X	X	X
Normal instrument take-off	X	X	X	X
(normal instrument)	X			
Engine failure take-off	X	X		
Rejected take-off	X	X	X	
Climbing turns				
Normal	X			
Engine inoperative	X			
Lateral control	X			
Tuck and mach buffet	X			
Runaway stabilizer	X			
Jammed stabilizer	X			
Approach to stalls	X			
Flight characteristics	X			
Steep turns	X			
Cruise control	X			
Emergency descent	X			
Areas arrival and departure	X			
Use of navigation and communication				
Equipment	X			
Holding	X			
Flt. dir. ILS approach				
Normal	X	X	X	X
Engine inoperative	X	X	X	
Autopilot	X			
Non-precision approach				
VOR	X			
ADF	X			
Bkse	X			
Circle	X	X		
Missed approaches				
ILS	X	X	X	
Engine inoperative	X	X		
Non-precision	X			

TABLE F-1-1. MANEUVERS REQUIRED TO BE SATISFACTORILY PERFORMED IN THE AIRPLANE DURING DC-8 CAPTAIN TRANSITION (CONT'D)

	2/69	11/70	'74	'77
Landings				
Normal VFR	X	X	X	X
From ILS	X	X	X	
1 engine inoperative	X	X	X	X
2 engines inoperative	X	X		
Zero flap	X	X		
Rejected	X	X	X	
Stablizer out of trim	X			
Engine fire				
Air	X			
Ground	X			
Manual flight control approach	X	X	X	
Engine(s) out maneuvering	X			
First officer duties	X			
Engine shut down and relight	X			
TOTAL	43	16	11	5

- 6 simulator periods of 4 hours each
- 1-1/2 hours for flight training
- 1-1/2 hours for FAA aircraft rating

As is evident, the introduction of this program, incorporating "Learning by Doing" in all phases of training, cut ground phases of training time in half when compared with older methods. The efficient use of simulator time cut flight phases by a factor of 5 in course length and a factor of 8 in maneuvers required to be performed in the aircraft. This approach has reduced training expense considerably, while at the same time graduating more proficient and better qualified airmen.

F.3 GENERAL APPLICATION TO THE MARINE WORLD

In training to proficiency, one must examine the knowledges, skills, and personal characteristics deemed necessary for the performance of the given task. The specific behavioral objectives approach to training and certification requirements uses the latest in program methodology to ensure that all graduates are equipped with pertinent knowledge, skills, and personal characteristics.

Knowledge elements can be taught for the most part in a classroom setting with the proper training aids. The knowledge gained merely serves as an enabling function; it does not guarantee the ability to perform.

Skill, however, is the capability of applying knowledge in the performance of a given task. Certain skills can be learned only in the "real world", while others can be learned using part-task trainers, models, or other training aids and devices.

In many cases the ship handler may exercise only perceptual or cognitive skills, i.e., recall, recognition, problem-solving, concept formation, and multiple discretion. However, it is essential that he fully understand the relationships between the task he is asking the crew to perform and the physical response of the equipment (including all external and internal variables, e.g., wind forces, current direction and velocity, and loading factors). Such an appreciation can be gained only through personal experience. It is important that training programs and certification requirements adequately address the importance of proficiency in these skills.

Present schooling does not emphasize proficiency, but depends upon on-the-job, follow-on training for many of the knowledge elements and most of the skills to be transferred to the specific tasks by experience. Simulation is the solution to the voids that now exist in this area. The role of simulation is to reproduce practical situations so that experience can be gained in a selective manner under controlled and repeatable conditions.

Some of the knowledge and skill requirements that can only be incorporated through experience are:

- Shiphandling (navigation and piloting)
- Collision avoidance
- Restricted waters maneuvering

- Docking
- Internal and external ship forces
- Ship characteristics
- Relative motion
- Use of ground tackle

Personal characteristics must also be considered to determine the capability of the trainee in handling all the aspects of this future position. Some of these are:

- Confidence
- Concentration
- Self-control

Obviously, the presence and extent of these characteristics is difficult to measure under any but operational circumstances.

Presently, marine training is using actual hands-on experience to gain these skills, leaving the trainee at the mercy of his unprofessional instructor. The average ship officer does not appreciate his role in the scheme of training. The quality of instruction is contingent upon such variables as the technical capabilities of the tutor as an instructor and as an operator, and operational pressures on the instructor and apprentice.

On-the-job training, using the apprenticeship method, tends to inculcate the faults, as well as the attributes, of a master in performance, attitudes, and behaviors. The trainee will tend to copy the bad along with the good points of his instructor. Since there are no standard operating procedures, each master will add his own personal touch to each task, which will then be "personalized" by the trainee. Traditionally, the master himself has not been given any training specifically designed to fit him for the position. It is considered that since he has spent the required number of years at sea witnessing all sorts of things, he has learned enough to fit him for the top job. This may well be so, if he has served under masters who were prepared to explain their thinking and decisions to him and if he has been sufficiently interested to profit from this. If this is not the case, he is merely mechanically responding to certain stimuli himself, and therefore cannot explain the reasons for decisions he is making; i.e., he may not even be aware himself of the information he is collecting and processing and the problems he is solving that lead to his decision.

There is a strong need for various forms of standardization (operating procedure, bridge equipment configuration, etc) that would facilitate the training process and minimize adaptive demands. Individual trainees will vary in performance, but standardized procedures would result in less deviation from the norm, i.e., optimal performance.

The use of the flight simulator as a means to practice abnormal and emergency procedures and reduce stress during the instructional phase of these highly complex operational periods has marginally increased pilot's confidence and performance during the actual procedures, and undoubtedly contributed significantly to improving overall flight safety in the aviation industry. When considering the traditional maritime training approach, the master was tasked with the operation of his vessel's safety, which was his primary concern, and also with the training of junior officers. When faced with a complex or hazardous situation, his attention had to be focused on the situation, not on communica-

ting his thoughts and actions to subordinates. Therefore, the segments of operation which are the most critical and should be emphasized in a training program were given the least emphasis due to the master's concentration on the problems at hand.

Therefore, hands-on experience as a training technique is more effective when supplied synthetically, because it eliminates undesirable variables such as: relationships, operational stress, personality, and instructional capabilities. At the same time, it can introduce desirable variables such as: abnormal and emergency conditions and repetition without endangering human, mechanical, or economical considerations.

The training and certification syllabus in the maritime industry has been rather theoretical in nature. Little emphasis has been placed on practical application of the knowledge being acquired through the study program.

The validity of using simulators for practical training, whether in the aviation or maritime industry, has been documented in the literature. The benefits are obvious, the savings in both time and material substantial, and the initial cost of implementing such programs low in comparison to the investment they are protecting.

Another area this program must address is the formation of a joint MarAd/Coast Guard Training and Certification committee with representatives from industry, union, and manufacturing and experts in operation of equipment, configuration of equipment, and training technology and methodology. There is an axiom in the education world which states that if a man sees the relevance of his training, he will be more likely to respond to it. The relevance of training, and the certification of proficiency in the areas addressed by this training, must also be coordinated. The training must reflect the needs of the industry and the examination syllabus must reflect the training. If a seaman is given operational training, he should be certified in the operational environment and vice versa.

The validity of having lecturers in one institution running courses and independent examiners in another setting giving examinations is being questioned. Perhaps a joint committee might result in courses and examinations being conducted on the same equipment under the same roof by the same personnel. In this way the training courses can better adapt to the needs of the industry and examinations more effectively test the material taught in the course.

F.4 AVIATION TRAINING AND CERTIFICATION PROGRAMS

Simulation has been incorporated into all airline training and certification programs. As mentioned previously, the objective of introducing more practical, applications type training was to:

a. Reduce cost

b. Reduce emphasis on theoretical knowledge versus skills training

c. Increase "systems knowledge" with respect to operation

d. Increase emphasis on normal, abnormal, and emergency operating procedures

A summary of the training and certification sequence follows.

In initial training on a piece of equipment or transition from one position to another, the present program consists of:

9 days of ground school

24 hours of simulator training

1-1/2 hours of flight training

1-1/2 hours of aircraft rating

25 hours of line operating experience (i.e., carrying revenue-paying passengers over established routes with a check airman occupying the righthand seat)

Proficiency checks are scheduled twice a year for a captain, once a year for a first and second officer. They consist of a 4-hour simulator period where the crew member is asked to perform specific maneuvers and solve certain emergency and abnormal operational problems.

An ILVP (in lieu of proficiency check) may be substituted for an alternative proficiency check as desired. It is also a 4-hour period in the simulator where the standard maneuvers must be performed; however, if the captain completes his check (which normally can be done in two out of the four hours of simulator time allocated), he may practice unscheduled maneuvers for emergencies and non-normal procedures.

Recurrent training is required once a year for all crew members. It comprises two days of ground school (8-hour day). All normal, abnormal, and emergency procedures are covered including all pertinent systems information.

Route qualification is maintained by observing a trip on a particular route once a year in the jump seat, flying over the route, or by viewing a slide/tape presentation covering all approaches and environmental considerations. To be qualified on a route with special considerations, the procedure is as follows:

a. The airport and surroundings are illustrated on a slide/tape presentation

b. The captain must complete one simulator run in and one simulator run out

c. One trip must be made under the supervision of a check airman in the first officer's seat.

See TABLE F-1-2 for a matrix of the programs.

A line check is made.

F.5 COST ANALYSIS

In the aviation field, it is private industry's responsibility to train their airmen to proficiency without government subsidization. Since training is a system within the corporation, which must be cost effective, the industry has devoted much time and effort to their program development.

FIGURE F-1-4 shows the cost per instruction hour of operating an L-1011 simulator as opposed to the actual L-1011 aircraft. Needless to say, the efficient use of the simulator to eliminate the necessity to train in the aircraft has contributed significant cost savings to flight training.

For an analysis of projected flight officer training costs for 1978, see FIGURE F-1-5. Approximate cost per training exercise (including the estimated 157 requalification

completions, estimated 4,785 proficiency check completions, and 480 initial and transition completions) is approximately $3,354.85.

There is an obvious advantage to conducting as much training as possible in the simulator rather than the aircraft. As a matter of fact, there is an experimental program being conducted which would eliminate aircraft training altogether. Flight training and rating would be accomplished in the simulator. The flight officer's first encounter with the aircraft would be flying revenue-paying passengers for his route qualification in that piece of equipment relative to his position. Naturally, industry is the initiator of such programs, since they are faced with increasing difficulty in making a profit due to increasing:

a. Fuel costs

b. Salaries

c. Benefits

d. Landing fees

e. Equipment costs

But it is the responsibility of the FAA to validate recommendations and approve programs.

F.6 FAA ROLE IN AVIATION PROGRAMS

F.6.1 FAA as Regulatory Agency

The FAA is the regulatory agency governing the airline industry. As previously mentioned, the industry's training budget is quite extensive. The airlines, wishing to train their officers to proficiency at the least cost, have been leaning toward the increased use of simulator time in place of aircraft time, even to the exclusion of aircraft training time, for qualifying flight officers. Their first encounter with the aircraft would be acquiring mandatory line operating experience. The FAA must examine and evaluate these programs thoroughly prior to authorization, since the responsibility ultimately lies with them.

The FAA evaluates and approves all airline programs and checks. However, the fact that the FAA is licensing the individual as being a proficient airman on specified equipments, requires not only their endorsement of the course work, but the judgment of their inspectors to ensure that the training techniques are appropriate with respect to developing necessary knowledge and skills for each trainee. It is the FAA's responsibility to conduct these examinations. After ground school completion, the FAA conducts an oral examination.

After the simulation phase of flight training (6 periods), the FAA rates the trainee in the simulator. After the aircraft phase (1 period), they type rate him in the aircraft. At that time the trainee is required to complete a total of 25 hours of line operation experience under the supervision of a check airman. During that period an FAA inspector will board the plane and make a final judgment as to his ability to coordinate efforts of crew, take commands of situations, etc. Should there be any question regarding a trainee's comprehension, skill development, coordination of efforts, or command of any of these phases, the FAA observer may ask him to repeat all or a portion of that particular segment of the training program.

TABLE F-1-2. MAJOR AIRLINE PROGRAMS AND CHECKS

	Ground School	Simulator	Aircraft	Line Operating Experience
Initial (transition) and upgrading	9 days* Airline/FAA	6 periods** Airline/FAA	1 period Airline/FAA	25 hr Airline/FAA
Proficiency check – Semiannually		1 period Airline		
iLVP (In lieu of proficiency check) – Semiannually		1 period Airline		
Recurrent (Refresher) – Annually	2 days Airline			
Route qualifications – Annually			1 period Airline	Airline
Line check				Airline

* 1 Day is approximately 8 hours

**1 period is approximately 4 hours

	L-1011 Aircraft	L-1011 Simulator & Visual
Variable Costs[1]	$2,476	$280.36
Fixed Costs[2]	744	100.40
Total	$3,220	$380.76

(1) Aircraft includes instructor salaries and benefits, fuel, maintenance, aircraft servicing, insurance, landing fees, food, and other.

Simulator includes instructor salaries and benefits, engineering, and maintenance.

(2) Aircraft includes depreciation/rentals, maintenance burden, training department overhead, and corporate general and administrative expenses.

Simulator includes depreciation/rentals, direct overhead, and corporate general and administrative expenses.

FIGURE F-1-4. AIRCRAFT VS SIMULATOR COST PER INSTRUCTOR HOUR

Flight Operations Division Expense	1978 Profit Plan
Mgr. Fly. Supvr. S.O./Flt. Instr. Sals.	$ 3,565,000
Ground personnel salaries	1,352,000
Rent ground equipment - simulator and general	1,071,000
Other expenses	171,000
Subtotal training department	$ 6,159,000
Trainee salaries	5,072,000
Training allowances	631,000
Aircraft fuel, oil and taxes	924,000
Subtotal flight operation	$12,786,000
Other Division Expenses	
Aircraft maintenance, direct and burden	622,000
Aircraft depreciation, rent and insurance	399,000
Simulator, ground equipment, depreciation	507,000
Simulator maintenance	1,240,000
Employee benefits	2,636,000
Total training expense	$18,190,000
Training Aircraft House	
Initial and transition	1,508
Requalification	--
Proficiency	146
Recent experience	--
Total	1,654
Initial $ transition completions	480
Requalification completions	157
Proficinecy check completions	4,785
	5,422

FIGURE F-1-5. FLIGHT OPERATIONS DIVISION FLIGHT OFFICER TRAINING COST

As a matter of record, approximately 2 percent, or 1 in 50 trainees, are not endorsed by the FAA and must be retrained in a certain area.

At times an FAA observer certifies an officer only to have the airline's check airman report his performance as unsatisfactory. Although it is the responsibility of the FAA to license a crew member, it is ultimately the responsibility of the airline to provide for the safety and comfort of their passengers. To this end, the decision ultimately lies in their hands as to whether or not the flight officer will fly for their company.

Upon completion of these checks, the trainee is then authorized by the FAA to carry revenue-paying passengers for a major airline (with consideration being given to constraints on his license, such as position, type of aircraft, etc).

The airline's representative, or check airman, conducts all other checks (TABLE F-1-2), being responsible for the sequence of maneuvers, amount of discussion, repetition of maneuvers, etc. These are randomly observed by the FAA to ensure compliance with training specifications and standards as set forth in the Federal Air Regulations.

F.6.2 Qualification of FAA Inspectors

The Federal Aviation Administration has its training center in Oklahoma City. Each inspector is, when hired, a qualified pilot. He must attend a 5-week indoctrination program which covers all aspects of his job, such as observation of crew members, equipment certification, training aid specification, and monitoring, etc. The basic indoctrination course categorizes the inspector's responsibility into three areas:

- Operation
- Maintenance
- Avionics

All air carrier inspectors are specialists who are required to hold the same rating and training as airline pilots and are themselves certified as proficient officers on at least the category of aircraft (e.g., widebodied or 747 and A300 as opposed to 727 and DC-9) if not the actual piece of equipment. They must maintain that proficiency and the identical medical standards as airline crew members.

The Coast Guard and the FAA share some common responsibilities in their respective industries. The airlines have found that as the FAA's power to regulate increased with the Aviation Act of 1958, the regulators who would ultimately judge the abilities of these highly trained, professional airmen must themselves be skilled in the behaviors they are judging. This ensures the respect of those being observed, gives credibility of judgments made, and allows decisions to stand unchallenged.

F.7 SPECIFIC LESSONS FOR MARINE OPERATORS

F.7.1 System Team Training

In system training program exercises, the crews in the system practice as a component of that system or as a team to improve their individual performance and coordination of individual effort into a team effort. This contributes to a feeling of:

- Group belongingness
- Group participation
- Group problem orientation
- Understanding of procedures
- Understanding of the group's problem
- Understanding of the group's interaction

As was mentioned previously, the systems approach to training merely signifies that training will be operationally relevant and concerned with the equipment functions rather than its makeup. When observing bridge procedures, the interaction necessary for the coordination of efforts would most certainly be enhanced by some level of team training. When considering complex man-machine interface with respect to the operation of a huge tanker, one can clearly see that isolation from the functioning of the entire system is not feasible. Therefore, men must be trained as a team, achieving specific objectives with respect to the machines within the system and their optimal operation.

The aviation industry has used team training, successfully breaking it up into three phases:

- Individuals trained in procedures and doctrine (slide/tape CPM presentations)
- Team members instructed as a unit, learning the interactive and communicative requirements of team functions (Cockpit Procedures Trainer)
- Tactical training in which teams apply the procedural and interactive skills they have acquired to situations requiring innovative and creative behavior (simulator)

As is evidenced by this flow, studies and direct application have shown that team training can only be efficiently employed when individual proficiency has already been developed. The initial phases should be concerned with the individual's attaining all the required knowledge and procedures inherent in his job. These can then be applied to the acquisition of coordinative skills. Team training is especially effective when the tasks being trained are such that formal rules cannot be stated and procedures must be developed by the coordination of efforts in the process of task accomplishment. The fact that one member of a team must compensate for the deficiencies of another member is one of the basic principles in team training.

The training of crews for emergent situations which call for decision-making and problem-solving skills is best handled with a team training approach because:

a. Analytic solutions to the problems are not available

b. Environmental conditions are not reliable or predictable

c. The state of the system is not reliable or predictable

d. All tasks and activities cannot be specified

Using team training produces a coordinated performance which effectively becomes more than the sum total of individual skills alone. The safety and proficient operation of the vessel depends on every member's performance and the interaction and coordination of all tasks and procedures.

Insofar as the training and certification of deck officers is concerned, specific application

of the team concept can be considered for the ultimate operation and development of coordination in final stages of shiphandling training. Team training does not transfer well with low fidelity simulation.

F.7.2 Multimedia Approach

In establishing a training program for transition, upgrading, refresher, or other training for deck officers, the multimedia approach used by the aviation industry has definite application. Instruction that is automated:

a. Eliminates instructor skills variables

b. Eliminates trainee/instructor relationship

c. Presents uniform coverage of subject matter

d. Allows for individual differences in learning ability

e. Ensures a precise end product

The instructor becomes a manager of student learning. By assigning more or less individual study, trainers repeat certain sectors of a program, constantly providing knowledge of results, and encouraging post-exercise discussion, the instructor motivates his trainees toward optimal performance.

Knowledge of results is very important for learning effect and sustained team proficiency because it reinforces the correct behavior and redirects behavior when necessary. Feedback is provided from:

a. Intrinsic sources, or feedback which is inherent in the performance of the task; e.g., alarms or indicators will respond to an incorrect procedure or a ship is grounded.

b. Extrinsic sources, or feedback which is provided by an instructor in the form of guidance, redirection, debriefing, and discussion.

The creation of audio/visual packages required the skills of the graphic artist, photographer, and sound engineer for technical quality; the knowledge of the subject specialist for content; and the guidance of a person versed in education method. Such work takes time and expense initially, but once produced can be reproduced rather inexpensively and re-used repeatedly until contents are no longer up to date.

Having an instructor available at all times, assigned to a specific team, allows for the constant vigilance necessary for providing evaluation, redirection, and meaningful knowledge of results. The more specific and precise the information that is provided to a trainee with respect to feedback/knowledge of results, the greater and more efficient the learning effect.

In traditional classroom settings and testing situations, instructors concentrated their efforts on lecturing, providing the information rather than analyzing each student's ability to assimilate and apply that information. Using the multimedia approach, the instructor is freed from his teaching responsibilities (which, as discussed previously in this section, are better covered by automated instructor which supplies more precise information) to provide the knowledge of results and reinforcement and motivation, which will

significantly augment his learning and ultimate performance.

F.7.3 Training Programs and Proficiency Checks

Advancements in navigational equipment, traffic separation and control, and operational equipment itself with its intrinsic safety controls have contributed to the enviable safety record of the airlines. The major emphasis, however, has been placed on licensing and training, standardizing procedures, cockpit discipline, flight crew monitoring and proficiency testing. An analysis of collision statistics shows that 70 percent of all commercial aviation accidents and near misses occur during takeoffs, approach and landing phases of flight, which represent the period of highest operator workload, and man-machine interface. Based on these statistics regarding the human factor in the cause of accidents, the industry, in order to increase their safety record, emphasized the training and constant vigilance of their crew members.

The concern over maritime safety has peaked in the last several years due to tremendous losses in equipment and/or cargo, loss of life, and the problem of pollution. However, the industry is drawing upon technology and innovation to answer their needs rather than addressing the fact that the majority of marine collisions, groundings, etc are in pilotage waters and occur mostly because of human failure. While equipment modifications and additions may have a significant safety effect, they alone will not increase safety. This is evidenced by the fact that:

a. In virtually all collisions, groundings, etc the shipboard systems provided did not fail and would have provided the necessary warning of danger in adequate time had they been employed properly.

b. The majority of errors were not professional misjudgments but failures to detect a problem in time for effective action.

The aviation industry's training programs and checks have been explained in section F.1.2.

In analyzing their training requirements the industry saw the need for operationally relevant:

- Initial training on equipment
- Recurrent training on that equipment
- Proficiency testing to ensure qualifications were maintained
- Route qualification

These programs have been designed to make the crew member sufficiently aware of his own limitations, those of others, and equipment limitations by ensuring that an extended passage is planned in adequate detail with contingency plans where appropriate; and that crew organization provides for:

- Comprehensive briefing
- Monitoring of equipment systems with relation to safety
- Cross checking of duty performance to ensure error elimination or early detection and correction

In the maritime industry, as the sea lanes have become increasingly crowded requiring

more precise maneuvering of a vessel, the need for operationally relevant training in these areas has grown. As discussed previously, there is no "training course" administered to advance from one class of ship to another, nor from one grade to another. The only requirement is that minimum time (specified by the USCG) is spent in grade, followed by a government-administered written examination for the next grade. That license entitles the holder to sail on any size or type vessel in that position.

These licenses do not ensure proficiency nor is there any requirement for proficiency testing on renewal, which is handled by the administration of a written examination every five years. Such a system requires the attainment of mere technical adequacy which can be achieved by following a narrowly conceived course leading to certificates of competency and renewal of these certificates.

An outline of a more comprehensive training program follows:

a. Transition Training. The purpose is to familiarize the trainee with equipment configuration changes, deviations in procedure and system standards from presently operated equipment. Normal, abnormal and emergency procedures are studied with emphasis placed on deviations from "standards". This program will address these specific aspects relevant to the maritime industry:

- Specific behavioral objectives to be trained for normal, abnormal and emergency procedures
- Breakdown of maneuvering characteristics
- Training approach
- Devices required
- Fidelity of devices
- Curriculum outlines to ensure operationally relevant training

b. Recurrent Training. The need for refreshing knowledge of normal, abnormal and emergency procedures in itself is an important consideration when weighing the pros and cons of a refresher program. Considering the technological growth in the maritime industry, it is evident that masters and pilots must be constantly updated to modification in system and performance standards. It is also imperative to refresh the knowledge and skills of a mariner who has been "grounded" for a period of time prior to his regaining command.

c. Upgrading Training. Training in this area should focus on the acquisition of knowledge and skills which were not a function of the master's previous position. A master is responsible for his ship at all times; however, in the local restricted waters so familiar to the pilots navigating in them, the master will usually defer to the pilot's judgment. Upgrading training such as is proposed would equip the master with more pertinent information and the ability to analyze the pilot's technical competence and decision making capabilities.

This, however, is only one application of upgrading training. It should be incorporated into the training scheme throughout the career of a seaman to introduce him to new aspects of his career.

As mentioned previously, training is a subsystem of a total system which must be cost effective. Under consideration here are the vast amounts of money that are spent investigating accidents, changing the construction of ships, fitting fail-safe equipment to prevent pollution, and avoiding collisions, etc.

Nearly 60 percent of operating costs for large tankers is attributable to insurance premiums which, according to the American Hull Insurance Syndicate, are not even covering losses. Further, in an analysis of collisions, strandings and machinery damage suites by the American Hull Insurance Syndicate during 1968 and 1969, it was estimated that damage due to negligence accounted for at least 85 percent of all losses.

It is not difficult to understand the impact human error has had on the level of insurance premiums and thus on operating costs. For a small percentage of money well spent, governments, industry and unions could invest in establishing training programs and setting up facilities to ensure that all mariners meet the highest standards and thereby provide solutions to the problem rather than merely treating the symptoms.

F.7.4 Fidelity of Simulation

Simulation has been established as a very valuable training tool. It effectively transfers the learning environment from an abstract setting (classroom) to a real or operational setting. Not only is simulation a more natural training environment, but the instruction and training process can be better controlled through the use of simulation. Some of these advantages are:

- Inputs can be readily manipulated to accomplish a particular training objective
- More effective knowledge of results is provided
- Emergency conditions and systems degradation can be introduced whereas the danger inherent in the practice of these procedures would preclude their use

However, simulation is only a representation of the "real world". The designer of a simulation-based training program must address the problem of the amount of deviation or departure from reality which is acceptable, or conversely the degree of realism necessary for the acquisition of particular skills and to ensure maximal transfer of training to live operations.

The program designer must address the fidelity of the stimulus situations as well as the system, its equipment and functions. He must consider:

- Critical tasks
- Instruments needed
- Precision of display

(For non-critical tasks, simulated displays may be less accurate, but for critical skills, information must be displayed in as realistic a fashion as possible.)

In stimulus situations it is necessary to:

- Show appropriate relationship between critical variables
- Incorporate realistic problems and situations of varying complexity from normal and emergency to broaden the experience base of the trainee and cultivate flexibility and adaptability

The designer must also optimize the relationship between fidelity, transfer of training, and cost. Factors which influence this relationship are:

- Quality of instruction
- Objectives of instruction
- Pre-simulation instruction

However, in weighing the overall relationships among fidelity, cost and transfer, the most important factor to consider is the goals of training. The danger of practicing certain emergency procedures under live conditions would preclude this training from being carried out in the actual equipment. However, the criticality of these procedures may be such that when the occasion arises where these procedures must be employed, the crew must be confident, coordinated and aware of what must be done.

As discussed previously, for transfer of training in emergent situations, only high fidelity simulators are acceptable to ensure perfect execution the first time the occasion arises for use of these procedures. Therefore it is imperative that simulator training be designed to meet the requirement that there be maximum transfer to the live situation in the first trial.

F.7.5 Check Lists and Manuals

Since the Aircraft Manual is such an important part of the training program in the aviation industry, the manual is designed in conjunction with the training course. It is used as the handbook for the course and as a job aid in the operational setting.

When designing course content of a systems training course, it is imperative to decide beforehand exactly what can be expected of job aids such as manuals, checklists, and other devices used to provide cues for actions or supply additional information as required.

The precise nature of such job aids should be stipulated so that subject matter can be built around the supports which will be available on the job. If the systems information is not crucial to emergency/abnormal procedures or is infrequently used, and it is readily accessible in a manual, the trainee need not be required to memorize this data.

To facilitate the efficient use of manuals on the job, the contents and training courses have been standardized for all aircraft. Therefore, should the second officer require additional systems information, he would know exactly where to find the necessary information in this manual expeditiously.

The rationale behind the aviation industry's use of checklists for normal and emergency procedures, is that a pilot is prone to "set" because of the intense concentration necessary for much of his work. He must, however, develop the ability to be aware of the state of different instruments and eventualities which may occur; this is known as "multiple set".

Under intense concentration or fatigue the pilot may shut out all stimuli but one, and he becomes set on one instrument or one course of action. In order to avoid this, the airplane has been fitted with many safety devices which warn the crew when certain procedures have not been performed. For example, a warning signals when the airplane has descended to a certain altitude and the landing gear has not been put down. However, the pilot must always be aware of what is happening in relation to many other variables, and at times concentration may become so intense that the alarm may be silenced and the procedure never completed.

However, with the use of checklists, the second officer is tasked with verbally calling out all of the required tasks and subtasks which are necessary and the captain or first officer must reply with the appropriate response indicating completion of a task for which he is responsible.

During emergency or non-normal procedures (procedures which must be memorized), the checklist will be referred to at the first opportunity on the procedures recapitulated to ensure that every task and subtask has been completed.

In order to successfully incorporate checklists into the operational setting, procedures must be standardized. Then, the process of performing routine procedures correctly and in an orderly fashion becomes a habit. It is important that the captain and crew develop correct habits so that there will be a thoughtful and efficient response to situations as they arise. The captain is then free to apply his knowledge to problems which are unusual and cannot be solved by habit or procedure.

F.8 AVIATION/MARINE SIMILARITIES AND DIFFERENCES

Having a clear understanding of specific aviation programs and their potential applicability to the marine world will enhance our ability to see exactly where the two industries' approaches to training and certification differ and where they are similar. (See also TABLES F-1-3 and F-1-4.) A brief comparison follows.

a. Licensing -- . /iation Industry

Licensing requirements and procedures are controlled and administered by the Federal Aviation Administration for:

1. Type of engine or class of aircraft (gross weight)
2. Category of operation (private, commercial, airline transport)
3. Restricted visibility operation (instrument rating)

In order to obtain a license, an applicant must pass:

1. Written exam
2. Flight training
3. Flight test
4. Medical examination

All commercial aviators are fully qualified pilots prior to employment by an airline and are required to hold an airline transport rating for the specific type aircraft they will be flying. In order to obtain this rating he must:

1. Accumulate minimum specified flying time
2. Pass medical exam
3. Pass oral exam after ground school
4. Be type rated in airplane

TABLE F-1-3. INDUSTRY LICENSING REQUIREMENTS (AVIATION VS MERCHANT MARINE)

CERTIFICATION AND TRAINING REQUIREMENTS	AVIATION PILOT	MERCHANT MARINE MASTER		GENERAL INFORMATION
	REQUIRED	REQ.	NOT REQ.	
Transition				
Training	X		X	
Certification	X		X	
Recurrent (Refresher)	X	X		
Training	X	X		Radar Only (Merchant Marine)
Simulator Experience	X		X	
Certification	X	X		
Proficiency Check	X		X	
Specified Intervals	X		X	Aviation: every 6 mos, comprehensive. Merchant marine: every 5 years, limited
Simulator Experience	X		X	
Inspector Evaluation Real-Life	X		X	
Performance Measuring				
Simulator Evaluation	X		X	
Examinations	X	X		Merchant marine limited to written examination
Inspector Evaluation Real-Life	X		X	
Physical Fitness Evaluation	X		X	
Mental Fitness Evaluation	X		X	
License Restrictions	X		X	
Type	X		X	
Tonnage		X		
Qualification Standards for Licensing Inspectors				
Must have same qualifications as Renewal Applicants	X		X	

TABLE F-1-4. MERCHANT MARINE OFFICER LICENSING REQUIREMENTS (USCG): MASTER OF STEAM AND MOTOR VESSELS OF UNLIMITED TONNAGE UPON OCEANS

LICENSE RENEWAL REQUIREMENTS: RENEWAL EVERY 5 YEARS

RENEWAL TASK	REQ.	NOT REQ.	GENERAL INFORMATION
Operational Experience	X	X	No specified time required
Training			
● Equipment Operations			
Radar	X		3 hour refresher course
CAS		X	
General		X	
● Operational Procedures		X	
● Systems Information		X	
● Maneuvering and Shiphandling Techniques		X	
● Emergency Procedures		X	
● Cargo Handling Procedures		X	
● Engineering Management		X	
● Leadership		X	
● Vessel Management		X	
SOLAS		X	
Administration		X	
Proficiency Requirements			
● Oral Comprehensive Exams		X	
● Written Comprehensive Exams			
Pollution	X		90% acceptable
Rules of the Road	X		90% acceptable
Navigation		X	
Operational Procedures		X	
Systems Information		X	
Maneuvering and Shiphandling Techniques		X	
General Seamanship		X	
Emergency Procedures		X	
Cargo Handling Procedures		X	
Safety		X	
Vessel Management		X	
● Practical Exams			
Radar/Signalling	X		
Shiphandling and Maneuvering Capabilities		X	
Ability to Assume Command of Situations		X	

TABLE F-1-4. MERCHANT MARINE OFFICER LICENSING REQUIREMENT (USCG): MASTER OF STEAM AND MOTOR VESSELS OF UNLIMITED TONNAGE UPON OCEANS (CONT'D)

RENEWAL TASK	REQ.	NOT REQ.	GENERAL INFORMATION
Emergency and Non-normal Procedures		X	
Equipment and Systems Operation		X	
Operational Procedures		X	
Cargo Handling Capabilities		X	
Decision Making Capabilities		X	
Simulator Training		X	
Route/Port Qualification		X	
Intermediate Refresher Training		X	
Intermediate Proficiency Examinations		X	
Vessel Type Restrictions		X	
Final On-board Proficiency Test		X	
USCG Certification for Licensing Merchant Marine Officers - USCG Inspectors			Inspectors not required to have similar qualifications as renewal applicants

As previously mentioned, proficiency checks are repeated every six months, medicals, recurrent training and certification to fly a specified route are annual.

b. Licensing – Maritime Industry

Initial licensing is issued after completion of a course of study at a government-sponsored maritime academy and minimum time serving as a cadet. Licenses are issued according to:

1. Types of vessels
2. Tonnage
3. Waters

An ocean license qualifies the holder to sail any vessel without regard to size or type in his position. To obtain a license the holder must:

1. Serve a specified number of hours in grade
2. Pass a written examination, theoretical in nature, administered by the government

Licenses are reviewed every 5 years. Requirements for license renewal are to:

1. Pass a written exam on Rules of the Road (open book)
2. Have service on a vessel (not necessarily in grade) or related on-shore job within preceding 3-year period
3. Pass a color blindness test
4. Have a radar endorsement

There are however, no follow-up performance tests, no periodic proficiency tests, and no restrictions as to size or class of ship.

c. Training – Aviation Industry

Airline and commercial training schools and programs must be approved by the Federal Aviation Administration. Descriptions of major airline training programs, devices and methodology are contained in section F.4. Simulators and training devices must also be approved by the FAA to ensure specifications have been met by the manufacturers. These are checked for proper functioning and maintenance of fidelity every 90 days. Instructors and check airmen are specialists, well-versed in training techniques, as are FAA inspectors. Training of these professionals emphasizes:

- Normal
- Abnormal
- Emergency procedures
- Equipment modifications or variations (FAA approved)

d. Training – Maritime Industry

Initial training is given at maritime academies with a potential officer advancing through the ranks with no formalized training required by regulation. As mentioned previously, the training of junior officers is left in the hands of senior officers who may or may not be qualified or so inclined to provide this training. Subsequently ship owners faced with the problems inherent in such a poorly disciplined system, are setting up their own programs using simulators and scale model vessels to teach shiphandling. Through a more standardized approach to operating procedures (normal and emergency) problems should be alleviated. Deficiences include:

- No formal operationally relevant training (shiphandling and maneuvering)
- No formal training for advancement or transition
- No formal procedure training (normal or emergency procedures)
- No recurrent training

EXHIBIT F-2

NUCLEAR POWER PLANT OPERATOR TRAINING

F.1 INTRODUCTION TO NUCLEAR POWER PLANT OPERATOR TRAINING

By the year 1982, the numbers of nuclear oriented plant and headquarters personnel will have increased by approximately 15,500. To ensure safe, efficient operation and an increase in investment return; a cost effective training system for plant personnel is needed.

The three prime factors to be considered in the training of nuclear power plant operators are: (a) it absorbs the time of skilled men; (b) it requires operational equipment; and (c) the training is often difficult and potentially dangerous.

Once a nuclear power plant is operational, there is little opportunity to use it for training since all but routine procedures will adversely affect plant reliability, plant economy, and public and personnel safety. The use of nuclear power plant simulators in training and requalification programs for nuclear reactor operators and key plant personnel then, seems to be most feasible.

This paper will examine licensing and regulatory requirements, give a career profile, review an example of a complete training program, and outline all testing phases. It will also examine the use of simulators based on current and future training needs.

F.2 REGULATIONS AND LICENSING

The Atomic Energy Act of 1954 requires the Nuclear Energy Commission, its regulatory and licensing body, to:

a. Prescribe uniform conditions for licensing individuals as operators of licensed production and utilization facilities

b. Determine the qualifications of such individuals

c. Issue licenses to such individuals

The Nuclear Regulatory Commission's requirements are implemented by the Code of Federal Regulations, Energy, Part 55, as of January, 1977. This document specifies all elements of the operators' license application, exceptions, testing, actual licenses, modification and revocation of licenses, certificate of medical exam, and enforcement. The requalification programs of the CFR are outlined in Appendix A of the above document. All facets of training, testing, and requalification of operators are explained and must be conformed to.

There are two levels of licenses; (a) operators, and (b) senior operators. Once an individual becomes an operator, he can be recommended for the position of senior operator by plant management decision. Before any license can be issued, three criteria must be met:

a. A satisfactory medical determination

b. Successful completion of the written and operating tests

c. Evidence that the applicant's services will be utilized

Each license expires two years after the date of issuance, unless the Commission has taken earlier action. The need for a licensee's services at any given facility must once again be proven.

For renewal of a license (for a senior operator, the extent of his activity in directing operations) the following must be presented:

a. A description of the requalification program completed (of which all records have been retained)

b. Evidence that the applicant has discharged his responsibilities safely and completely

c. Medical examination report

F.3 A CAREER PROFILE

A typical operator has at least six years of Navy experience. This experience is considered part of the training process as indicated in TABLE F-2-1. The process continues as the trainee proceeds through an individualized basic refresher curriculum. Upon completion of the refresher training, a four month systems training program describing the operating characteristics of various commercial plants as well as various administrative procedures is initiated.

At the conclusion of this course, the trainer receives six to seven months of on-the-job training before initiating simulator training. For license certification by the NRC, a two day testing program which consists of an eight-hour written exam and a four to six hour "walk-through" must be successfully completed.

Each site is free to create its own training program; however, the content and the materials used must be approved and must meet the standards established by the Nuclear Regulatory Commission.

F.4 REFRESHER TRAINING

Refresher training is an integral part of any training program. It is required and is strictly regulated by the Nuclear Regulatory Commission based on the trainee's level in the system. For example, the operator, senior operator and shift supervisors are required to participate in a refresher training program which consists of 56 hours of refresher training, including emergency techniques, every six weeks. Also, an annual exam is administered to trainees of all levels. The trainee must obtain a score of at least 80 percent for each section, and an overall minimum score of 70 percent. If the trainee receives a score of less than 80 percent in any area listed, he must receive intensive training in that area during the next year. See TABLE F-2-2 for further training requirements.

F.5 THE NEED FOR NATIONAL STANDARDS

At the present time a variety of training programs and standards exists. To provide for continuity of training, however, national standards must be established, Hughes and

O'Halloran (1974) indicate that national standards for nuclear power plant operator training would:

a. Clearly define the training requirements to be met by the simulator

b. State the simulation tolerances necessary to meet the training requirements for both system performance and system interdependency

c. Specify the fidelity and scope of simulation of normal, emergency, and abnormal operating conditions required for training and requalification programs

d. Provide criteria and guidelines to be followed by both the simulator manufacturer and the utility while cooperating with the AEC, regarding the use of a simulator in training and requalification of operators.

F.6 CONCLUSIONS

With the increasing demand for use of nuclear power, and considering potential hazards to public welfare and the costs associated with plant down time, the management of the nuclear power industry must:

a. Eliminate those factors which jeopardize safety of operations

b. Enhance those factors which affect the efficiency of operation and increase the return of investment

TABLE F-2-1. APPROXIMATE TIME INVOLVED IN THE TRAINING PROCESS

TIME INVOLVED	TRAINING RECEIVED
At least six years	Navy experience
Variable	Basic refresher
Four months	Systems training and administrative procedures
Six to seven months	On-the-job training
Variable	Simulator experience
Two days	Final-two days of testing. Eight hour written exam and a four to six-hr "walk-through"

TABLE F-2-2. TRAINING TECHNIQUES UTILIZED ACCORDING TO LEVEL OF TRAINEE

	TYPE OF TRAINING					
	SIMULATION	OPERATION	TRAINING COURSES	QUIZZES	EXAMS	WALK-THROUGH
Level of Trainee						
Operator	Extensive in initial phases; Requalification—every other year for 24 hours.	Hands-on as much as possible, on-the-job when possible	Intensive, five days every six weeks Requalification	Many self-study	End of year final	For initial license then each two years thereafter
Senior Operator	Same as operator	Same as operator	Same as operator	Same as operator	Same as operator	Same as operator
Management (i.e., shift supervisor)	Every year	Optional	Necessary for requalification	Can be used	For requalification	Same as operator
Instructor	Optional	Optional			For requalification	If desired

APPENDIX G

PHASE 2 PLAN

G.1 INTRODUCTION

This appendix presents the Phase 2 plan, the objective of which is to collect empirical data pertaining to the design of training system elements (i.e., simulator and training program characteristics). This objective is in direct response to the findings resulting from Phase 1 which have identified a wide variey of important design issues for which little objective data are available. Empirical data can be generated pertaining to the relative effectivenesss of different training system characteristics with regard to specific mariner skills -- in essence, the effectiveness of different simulator and training program characteristics in achieving improved shiphandling skills. The CAORF simulator will be the vehicle on which the investigations will be conducted. CAORF will be configured to represent the alternative training system characteristics (i.e., including alternative training program characteristics) with groups of trainees investigated. In this manner, objective cost effectiveness information can be generated.

The experimental plan has been developed, although the specific variables, skill areas, and so on have not. These will be determined via discussion with the working group.

The problems and issues identified in Phase 1 are typical of those which face the designer of any training program. The resolution of these problems requires in-depth investigation. As Blaiwes and Puig (1973) state "The best mixture of academic training, on-the-job training, and simulator time, and the sequence in which they should be presented involves complex experimentation." Phase 2 will attempt to clarify several of the more important issues facing the design and use of simulators for training in the maritime industry. Phase 2 will empirically investigate the effectiveness of training on a ship maneuvering simulator, including identification of the skill areas best suited to simulator-based training and other factors affecting its effectiveness.

Research and development areas that require further investigation, each of which is associated with a variety of issues, are listed in the respective appendices of this report. Inspection of these reveals a wide variety of issues that require further investigation. Several areas are recommended for investigation at this time, as discussed below. The specific issues to be investigated in Phase 2 will be selected on the basis of projected cost, likely effect on training, and importance (e.g., result of accident investigations).

Perhaps the single most important issue concerns the use of simulators to develop and demonstrate skill. This issue concerns the delineation of the effectiveness of a simulator in training particular skills, as well as the effectiveness of alternative simulator configurations in doing so. In particular, which skills can be effectively trained on a simulator, and which skills can be more effectively gained through experience? This issue is fundamental to the design and use of simulators and training programs. For example, certain skills, particularly those associated with emergency shiphandling, appear to be most readily learned on a simulator. Conversely, management skills appear to be most readily learned at sea. A wide variety of skills may fall somewhere in between.

The particular simulator configuration may greatly affect the effectiveness with which training can occur. In practice, the simulator and training program should be tailored to meet the training needs of a particular set of training objectives. The effectiveness of that simulator in meeting other objectives may be less than optimal, since it would have been designed for another purpose. The following variables address the effectiveness of alternative configurations.

The major components of a simulator-based training program are: (a) the training content (e.g., skills to be trained); (b) the context of materials (e.g., scenario); (c) the training methodology; (d) the simulator characteristics; and (e) the trainee characteristics. The training content was noted above as representing the goal toward which the simulator/training program should be designed. This issue is widely accepted as being of paramount importance to simulator design. Skill categories are considered as one of the independent variables in the experiment.

The second component, the context, is often overlooked in the training system design. Characteristics of the training material can have a substantial affect on training effectiveness (Blaiwes and Regan, 1970). The scenario design, a particular subset of training material, will be included as an independent variable in the experiment.

The training methodology is the framework around which the training process is carried out. A variety of issues are relevant to investigate in this regard. The utilization of the simulator is of paramount importance in the problems under investigation; hence issues impacting simulator use should be investigated. One of the most overlooked aspects of simulator-based training is the utilization of the computer's capabilities to enhance the training process (Hammell, Gasteyer, and Pesch, 1973). It is proposed that issues regarding this should be investigated in Phase 2.

The simulator characteristics have received considerable emphasis in discussions of training system design, in particular regarding fidelity (e.g., Blaiwes, et al, 1973; Blaiwes et al 1970; Hammell et al, 1973). The issue of fidelity is considered to be of great importance to simulator effectiveness and cost. A fidelity issue having a large impact on cost will be investigated in the Phase 2 design.

The final component, trainee characteristics, will not be considered as an independent variable. The trainees will all be at an equivalent level of entry skill, or at least balanced to remove differences.

The four components noted above, together with a trained versus untrained variable, will comprise the Phase 2 experiment. The specific variables and levels will be determined in an integrated fashion early in Phase 2.

The Phase 2 investigation will seek to identify those mariner shiphandling skills most amenable to simulator training. It will also identify tradeoffs between alternative simulator/training program characteristics in achieving an effective training process. The results will not only impact training simulator design, but will also contribute to the development of the training program acceptance criteria.

G.2 TECHNICAL APPROACH

The Phase 2 technical approach is segmented into five parts, as shown in FIGURE G-1. The experiment and supporting materials will be developed in Parts I through III, culminating in the Pre-Simulation Report. The experiment will be run, and data collected and analyzed in Parts IV and V, culminating in the Final Report.

Part I, the Experimental Design, will structure the experiment, identifying and selecting the various factors to conduct an appropriate and well controlled experiment. The experimental model and procedures will be developed, completing the blueprint for the subsequent development of material and conduct of the experiment. The tasks in Part I will draw heavily on the work accomplished during Phase 1. An Experimental Design

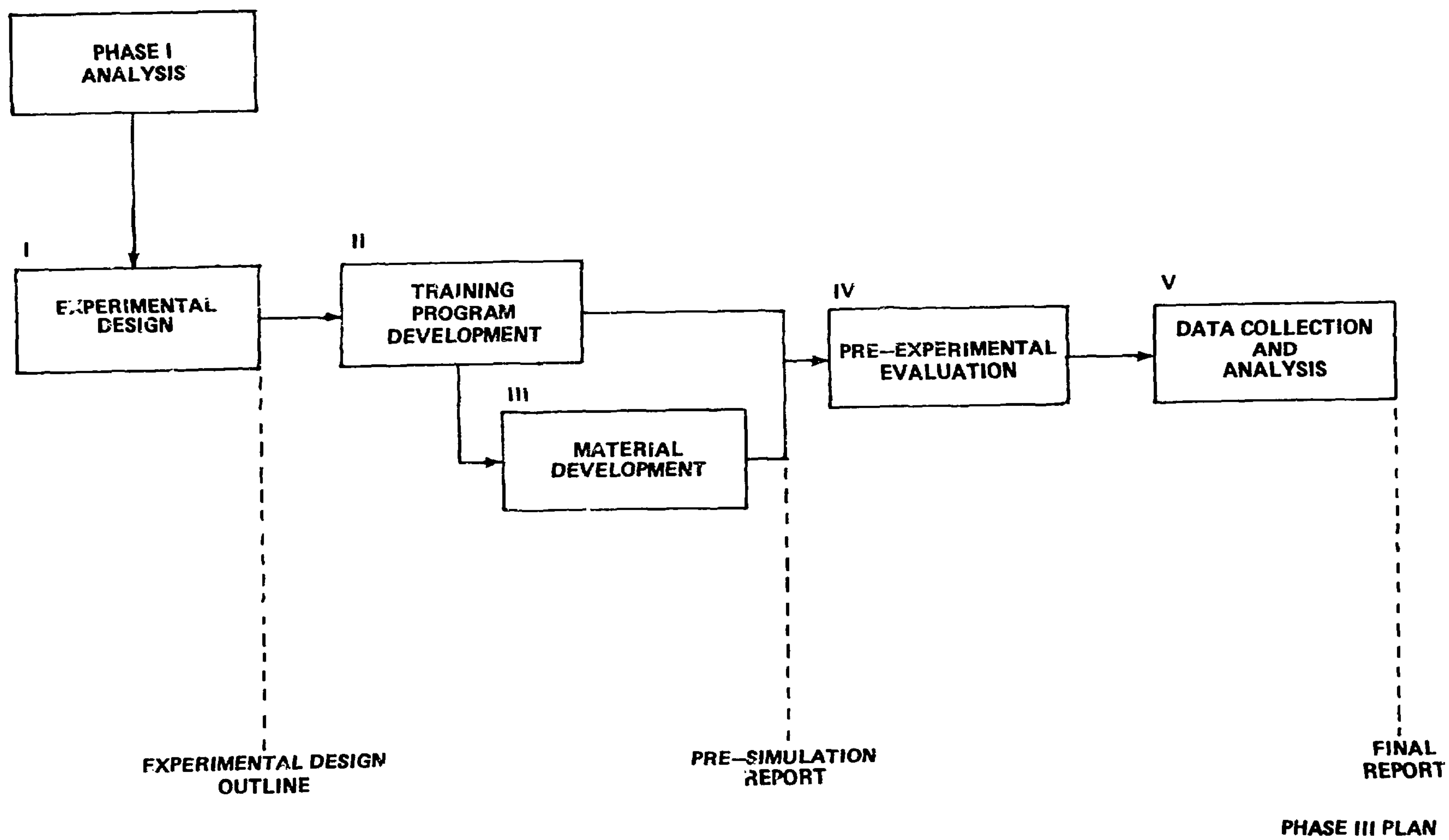

FIGURE G-1. PHASE 2 FLOW DIAGRAM

Outline will be developed and submitted at the end of Part I. This document will outline the research project, enabling USCG/MarAd to modify the design, procedures, etc, at an early stage, prior to the development of materials.

The training program will be developed during Part II. This will include the design and development of curriculum, both classroom and simulator-based, and the specification of supporting material requirements. The supporting material will be developed in Part III. The material will consist primarily of (a) software, such as modification of existing visual data base characteristics; (b) classroom material, such as visual aids; (c) tests, including simulator-based pre- and posttraining tests; and (d) training technology support, such as feedback information. The Pre-Simulation Report submitted at the end of Part III will detail the experiment, procedures, and supporting material.

Several pre-experimental evaluations are planned during Part IV. These evaluations, the plans for which will be presented in detail in the Pre-Simulation Report, will investigate various aspects of the experiment, the training program, and the supporting material. Modifications, prior to the experiment, will be made on the basis of these evaluations. Part V follows these pre-experimental investigations. It consists of the experimental data collection and analysis, and the development of the final report. The integration of the results into the Long-Term Plan will be addressed in the report along with a plan detailing subsequent research and development requirements.

The Phase II effort will be primarily a simulator-based experiment investigating the effectiveness of various training-related variables. A multidisciplinary approach is called for, emphasizing (a) training, (b) simulator design, (c) ship maneuvering skill, and (d) experimental design and analysis. Hence, the project team will consist of a mix of disciplines including (a) training specialist, (b) simulation specialist, (c) software specialist (i.e., CAORF), (d) maritime consultant, (e) experimental design specialist, and (f) CAORF setup, operation, and analysis personnel.

Each part of Phase 2 is presented below in greater detail.

G.2.1 Part I. Experimental Design

The objective of the experimental design is to develop the structure under which the experiment will be developed, conducted, and analyzed. The flow chart of the experimental design, shown in FIGURE G-2, includes 10 tasks. The tasks in Part I, although straightforward, require a complex balancing of factors to achieve a workable and efficient experimental design. The flow of tasks (as shown in FIGURE G-2) requires an iterative process for many of the tasks, since the experimental design will be achieved by reaching a balance between the many factors involved. Tasks 2 through 6 will occur in parallel; these represent the major factors that determine the design. The remaining tasks will derive from these.

The primary product of this part will be an outline of the experimental design, identifying the approach, variables and levels, subjects, experimental model, analysis approach, procedures, and other factors for designing, conducting, and analyzing the experiment. The task products of Part I are listed in TABLE G-1. A description of each task follows.

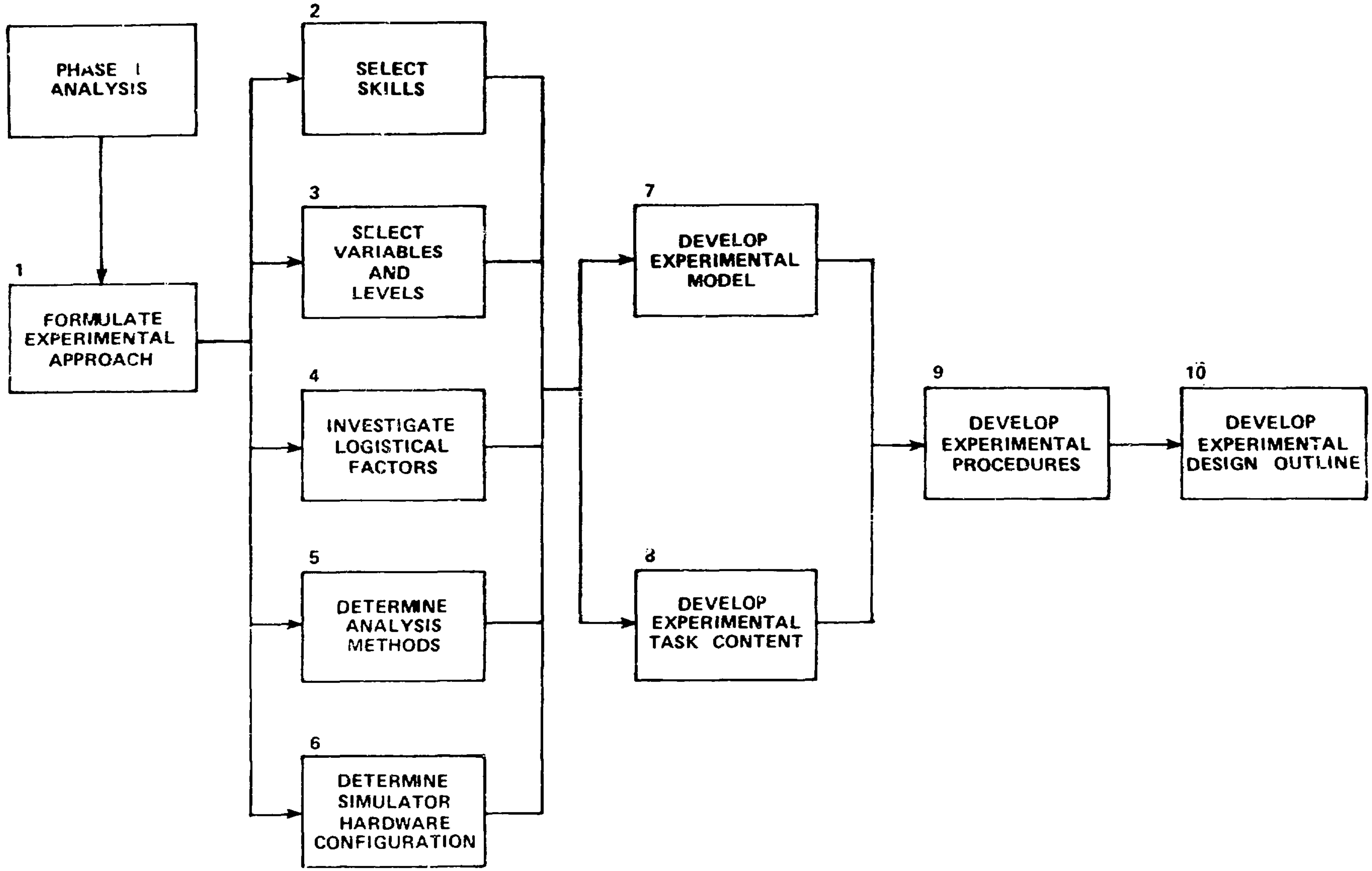

FIGURE G-2. PART I - EXPERIMENTAL DESIGN

TABLE G-1. PART I - TASK PRODUCTS

Task	Task Products
1	Experimental objectives
1	Experimental approach
1	Experimental constraints
1	Investigative issues
2	Selected skills
3	Independent variables (3)
3	Levels of the independent variables (2)
4	Subject qualifications
4	Simulator use description
4	Description of material required
4	Tentative experiment schedule
5	Analysis approach and methods
6	Simulator configurations
6	Approach to achieving alternative configurations
7	Experimental model
7	Number of subjects
8	Description of the experimental tasks
9	Description of familiarization period design and procedures
9	Run procedures
9	Prebriefing procedures
9	Post-run briefing procedures
10	Experimental design outline

Task 1. Formulate Experimental Approach

The objective is to (a) define the experimental objectives, (b) develop the experimental approach, and (c) define the experimental constraints.

Pertinent experimental issues will be identified, based on the Phase 1 data. These may concern device fidelity, training technology, and scenario design. These three categories have been selected on a preliminary basis, since they represent major concerns of effective simulator-based training; other categories may be substituted, depending on this analysis. The issues will be identified on the basis of skills, importance indicated by the literature (i.e., training and accident), cost of purchase and operation, potential effect on training, feasibility, and acceptability. The issues selected will provide the experimental objectives. The specific independent variables and their levels, which represent a further iteration, will be determined in task 3.

The experimental approach will be formulated on the basis of the experimental objectives. It will focus on the variety of considerations pertinent to the design and conduct of this experiment. These include cost, subjects, number of runs, time to develop material and so on. An area of primary concern is the type of training that will be provided. These considerations include: (a) area of training, such as emergency or normal shiphandling; (b) experience level of the subjects; (c) type of vessels; (d) purpose of the training; and (e) training conditions, such as open sea or harbor. The resultant approach will consist of an outline of how the investigation will achieve its objectives. It will be, in essence, a work plan for the investigation. The outline at this stage will be conceptual, establishing the macro-structure for the investigation. The detailed specification will be accc .plished in tasks 2 through 9.

Task 2. Select Skills

The objective is to select the subset of shiphandling skills for which training will be provided.

The area of training, such as emergencies, will have been selected in task 1. The particular subset of skills to be trained will be delineated in this task. This selection process will be based on (a) the appropriateness and potential to train on the simulator, (b) the feasibility of training within the constraints of this program, and (c) the importance of the skills. The selected skills will form the training program's objectives, for which the section level and topic level objectives will be developed in Part II. It should be noted that the selection of skills will be dependent on the independent variables and levels. Skills will be selected so as to bring out the differences in the levels of the independent variables, which is the goal of Phase II.

Task 3. Select Variables and Levels

The objective is to define a specific set of independent variables (i.e., experimental variables) with their respective experimental levels.

The relevant investigative issues will have been identified in task 1, under the categories of (a) simulator design, (b) training technology, and (c) scenario design. Examples of relevant issues identified to date are listed in TABLE G-2 under the respective categories. The independent variables to be investigated will be specific well-defined issues, selected

TABLE G-2. RELEVANT INVESTIGATIVE ISSUES

SIMULATOR DESIGN

- Color visual scene versus black and white
- Horizontal field of view
- Brightness levels
- Resolution
- Equations of motion fidelity

TRAINING TECHNOLOGY

- Group versus individual training
- Mix of simulator and classroom time
- Immediate versus delayed feedback versus demonstration
- Effectiveness of CRT - basic feedback display
- Instruction interface design

SCENARIO DESIGN

- Scenario length - short versus long
- Levels of fidelity - shipping, area of operation
- Port XYZ configuration versus specific port
- Effect of secondary information - e.g., weather forecasts chatter
- Levels of complexity

from those identified in task 1. It is expected that one independent variable, or issue, will be selected from each of the three categories. Furthermore, the levels of each variable will be determined during this task. For example, if the horizontal field of view (i.e., azimuth) were selected as an independent variable, two experimental levels may be chosen as (a) $0^{o} \pm 120^{o}$ relative and (b) $0^{o} \pm 60^{o}$ relative.

The selection of the independent variables and their levels must be accomplished in concert with the other factors of the experimental design to achieve a workable design. Experimental considerations, such as the device capabilities and the likely interactions with the other variables, must be addressed during the selection. The criteria on which the selection of the independent variables and their levels will be made for consideration in the experiment are: (a) potential effect on training effectiveness; (b) cost to implement and operate; (c) relative importance as determined by accident investigations and training literature; (d) feasibility to investigate on CAORF during Phase II; and (e) relevancy and acceptability to the maritime community.

The experiment will seek to determine the effect of the different levels of each of these variables on training effectiveness. It is expected that the main effects, rather than the interactive effects will be of greatest importance. This may allow the use of fractional designs to increase power in the effects of greatest importance, at the expense of the remaining effects.

Two additional independent variables will be included in the design. They are (a) training -- "trained" versus "untrained" conditions; and (b) skill categories (i.e., 3 categories) -- sets of similar skills. These represent primary issues to be investigated. Both the main and interactive effects between these variables are important, yielding information pertaining to the effectiveness of simulator-based training of specific skills. The final set of variables and levels will depend on the other factors, including the levels of effort allocated to the various tasks.

The particular analysis techniques and experimental model will affect the selection of variables and levels. They will be considered in tasks 5 and 7.

Task 4. Investigate Logistical Factors

The objective is to identify and evaluate alternatives pertaining to several logistical factors in arriving at the experimental design.

The logistical factors under consideration, each of which are addressed below, are:

a. Subject qualifications

b. Simulator functions

c. Material requirements

Subject Qualifications. A set of qualifications will be developed for the subjects, based on the experimental approach (task 1). These qualifications will be responsive to the objectives of the experiment, as well as to the practical considerations of obtaining subjects. Furthermore, they will define the entry skill level of the training program. The intention is to develop a set of tight qualifications to reduce subject variability and improve the power of the experiment.

Simulator Functions. The objective is to define the use of CAORF during the experiment, pertaining to the feasibility of achieving the independent variable levels and allocation of simulator usage during the project.

The CAORF capabilties represent a primary consideration in configuring the experiment. Issues to be investigated must be done so (a) within the capabilities to configure the simulator, and (b) within the level of effort designed for the project. Since the issues to be investigated will impact the configuration of the simulator (i.e., simulator design), and other simulator-based capabilities (i.e., training technology and scenario design), this represents a major factor in the experimental design.

The approach to be followed in this task will be to identify the simulator functions and their associated factors pertaining to the experimental design. These will include:

a. Simulator functions -- e.g., familiarization, training, testing

b. Operational context -- e.g., open sea, harbor, complex scanerio, simple scenario

c. Operating parameters -- e.g., field of view, brightness, exercise length

d. Method and extent of modifications required -- e.g., to change field of view, to add a CRT feedback display, to add secondary information. (Alternative methods will also be addressed.)

e. Level of effort to make modifications -- i.e., to establish the capability

f. Level of effort and constraints on changing conditions between runs -- e.g., between different experimental conditions

g. Costs

h. Amount of simulator use and schedule

This task will assist in arriving at the experimental design by providing important information for those decisions. In addition, it will generate a tentative simulator-use schedule at an early date to assist in CAORF advance planning.

Task 9 will be conducted closely with this subtask. Its purpose is to investigate the proposed simulator configurations to assist in determining the above factors and selecting the methodology.

Material Requirements. The material consists of those items that will be used in the accomplishment of the experiment. The material is made up of those items that currently exist and those that will have to be modified as developed. Several classes of material are expected to be necessary to support this project: They are:

a. The training exercises

b. Training aids -- for example, visual slides of ship tracks

c. The instructor's guide

d. Performance measures

e. Support software -- for generating performance measures, data collection, and data analysis

f. The simulator data bases -- visual and radar

g. Training technology capabilities -- e.g., feedback display, ship track plots

h. Performance tests -- e.g., pre- and post-tests

This task will identify, at a macro-level, the material requirements associated with each of these classes. The material requirements will be defined in terms of:

a. Content description

b. Effort to produce -- labor and training

c. Constraints on production and use

Task 5. Determine Analysis Methods

The objective is to determine the statistical techniques that will be used to analyze the experimental data.

The analysis methods will depend on several factors including (a) the number of variables and levels, (b) the form of the variables and dependent measures, (c) the objectives of the investigation, and (d) the experimental model. Each of these factors will be included in arriving at the analysis methods. Furthermore, the available methods will present a major factor in arriving at the experimental design. The analysis methods, together with the experimental model, will be selected on the basis of experimental efficiency and power.

The analysis of variance is expected to comprise the major statistical methodology. The experimental model will be designed to achieve an acceptable analysis of variance configuration. Fractional designs will be considered to maximize the statistical power for those effects of greatest interest. Additional analysis methods will be specific to investigate issues of secondary concern. These will be dependent on the particular experimental factors.

See task 7 for additional information.

Task 6. Determine Simulator Hardware Configurations

The objective is to investigate the feasibility of alternative simulator configurations, specifying the most appropriate.

A primary objective of Phase 2 will be the investigation of different levels of simulator fidelity. The other objectives may also require specific simulator configurations. The particular simulator functions and alternative methods of achieving the configurations will be addressed in task 4. The capabilities and feasibility of the simulator configurations to meet the objectives will be evaluated during this task.

The alternative configurations will be evaluated with respect to achieving the desired characteristics, and the feasiblity of using that configuration in an experimental context. The desired characteristics will be investigated as pertains to (a) achieving the specific characteristics (e.g., color visual scene, black and white visual scene); (b) limitations of the configuration pertaining to other characteristics (e.g., maximum brightness (i.e., daylight) may be reduced under black and white conditions); and (c) the effect on other

characteristics (e.g., brightness contrast may change when going from color to black and white). This investigation will show if the characteristics can be achieved, their limitations and effect on other characteristics, and other adjustments that need to be made in concert.

The feasiblity of using the configuration will be investigated with regard to: (a) the effort (i.e., time and cost) to develop the initial setup configuration, (b) the effort required to change to and from the configuration in the real time experiment context (this may constrain the experimental design and/or scheduling), and (c) the effort required to operate under the configuration.

This task will evaluate alternative methods of achieving particular simulator configurations as well as identify the feasibility of doing that in the experimental context. As such, it represents an important consideration in the development of the experimental design.

Task 7. Develop Experimental Model

The objective is to develop the experimental model for the Phase 2 experiment, specifying the characteristics of the experiment.

The experimental model is the particular combination of variables, levels, subjects, order of presentation of conditions, and analysis structure and methods to be used in the experiment. It will detail the analytical aspects of the experiment. It represents the culmination of tasks 2 through 6.

An analysis of variance approach will be followed as the primary design objective. The exact form has not been decided upon at this time, and will depend on completing the tasks 1 through 7. Certain bounds, however, can be placed on the design. Three independent variables are planned as follows: (a) simulator design, scenario design, and training technology, each having a minimum of two levels; (b) skill categories, with 2 or 3 levels; and (c) an "untrained" control group. Since the major experimental task will involve training, and investigating various training-related conditions, the experimental model is likely to be mostly of a between-subjects design. If the variables under (a) above are treated as between-subject variables, a minimum of eight groups would be required. Skill categories can be treated as a within-subject variable, not affecting the number of groups. The "untrained" control condition would add another group. Hence, as many as nine sets of conditions are possible, each requiring a minimum of six subjects. This design would be too expensive! Its requirements may be reduced by eliminating one or more of the independent variables and/or by using an incomplete design. One such approach would be to use a fractional design, which would place emphasis on the main effects, while playing-down the interactive effects. These issues will be looked at to develop an effective and efficient design with regard to specific research issues.

Task 8. Develop Experimental Task Context

The objective is to develop specifications for the tasks of the subjects.

The independent variables and skill categories will have been designated (tasks 2 and 3) prior to this task. The situational context within which the training and testing will take place will be developed during this task, based on those earlier decisions. This task will provide a description of the simulator-based situations, which the scenarios will be designed to achieve. The task context will specify:

a. Operational objectives (e.g., minimize the risk of grounding when a rudder failure occurs in a narrow channel)

b. The range of conditions

c. The trainee and instructor roles

d. The operational area -- general characteristics, and/or specific.

Task 9. Develop Experimental Procedures

The objective is to develop the experimental procedures to be followed in conducting the experiment.

The experimental procedures will detail the steps of the experimental process. The procedures will be relevant to four areas: (a) familiarization with CAORF, (b) conduct of training, (c) conduct of the experiment, and (4) subject groupings. The second area, conduct of training, will not be developed during this task, since it is a logical outgrowth of the training program development, Part II. Procedures for the remaining three areas will be developed under this task.

All subjects, both trained and untrained, will undergo familiarization training on the CAORF bridge. The purpose of this brief training program is to reduce the initial learning period that accompanies transition into the simulator environment. It will be designed to familiarize the subjects with the CAORF bridge, the nature of the experiment, and experimental procedures. The familiarization training program will be assembled from elements that currently exist. It will, however, be tailored to the specific needs of the subjects in bringing them to an equivalent level of expertise at the start of their experimental data trials.

The experimental run procedures will be developed to give a high degree of control and rigidity to the experiment. They will document the specific steps and instructions to be given by the instructor. The pre- and post-run briefings are actually a subset of the experimental run procedures. The importance placed on these briefings warrants they be called out separately. The procedures for these briefings will be carefully designed to (a) obtain the necessary post-run interpretive information, and (b) carefully control the information and influence transmitted to the subjects. These procedures complete the design of the experiment.

Task 10. Develop Experimental Design Outline

The objective is to develop an outline of the experiment for review sufficiently early, so as to permit the incorporation of comments and modifications as deemed necessary.

The outline is intended to summarize the objectives and structure of the experiment, enabling in-depth review prior to the extensive development of the training program and material. This will permit the review by the USCG and MarAd, and modification of the experiment as necessary at an early stage of development. The outline will summarize, in detail, the findings of the previous nine tasks, in essence presenting the experimental design.

The outline will be submitted as a brief document presenting the characteristics of the proposed experiment and its design. It will be supplemented with a verbal presentation to the interested parties -- USCG, MarAd, and industry.

G.2.2 Part II: Training Program Development

The primary objective of Phase 2 is to investigate the effectiveness of a ship maneuvering simulator as a function of various device and program characteristics. A training program is a necessary element of this investigation. The prototype training program will be developed during Part II.

The prototype training program will be developed to achieve the specific objectives as set forth under the experimental design. Several factors should be stated concerning the program: (a) the program will address ship maneuvering, (b) the scenarios will likely occur in harbor-type waters, where the accident frequency is highest, (c) the CAORF simulator will be used for a large proportion of the training time with a mix of classroom time, and (d) the program will span one week in duration, or less, per trainee group.

The approach followed in Part II is relatively standard, as shown in FIGURE G-3. The training program will be developed, including the instructor's guide, and the support requirements specified. A detailed description of the Part II tasks follows.

The Part II task products are listed in TABLE G-3.

Task 11. Develop the Training Program Structure

The objective is to develop the training program structure, including the section-level training objectives.

The course will be structured to achieve the specific behavioral objectives as specified in Part I. This will be accomplished by developing a set of section-level training objectives, which will be partitioned into blocks across the training program time period. This effort will delineate the scope of the course, the time frame and schedule; identify the instructor; break down the course sections; identify the trainee input and output characteristics; and provide a framework for accomplishing the remaining tasks of this part. It will be achieved by expanding the program objectives resulting from Part I into section level objectives. The training program guidelines developed in Phase 1 will be major input into this task. The other aspects of the structure will be developed by applying training management principles to achieve an appropriate structure.

Task 12. Develop Training Process Strategy

The objective is to develop the strategy by which an effective training process is achieved.

The section-level objectives specify, in some detail, what the training program will achieve. This task, together with task 13, will specify how the program will achieve those objectives. The training methodology to be used will be defined. This methodology will be defined for all aspects of the problem. It will address the following factors:

a. The training methods to be used (e.g., immediate versus delayed feedback)

b. The mix of classroom and simulator functions and time

c. Constraints on the training program (e.g., exercise length)

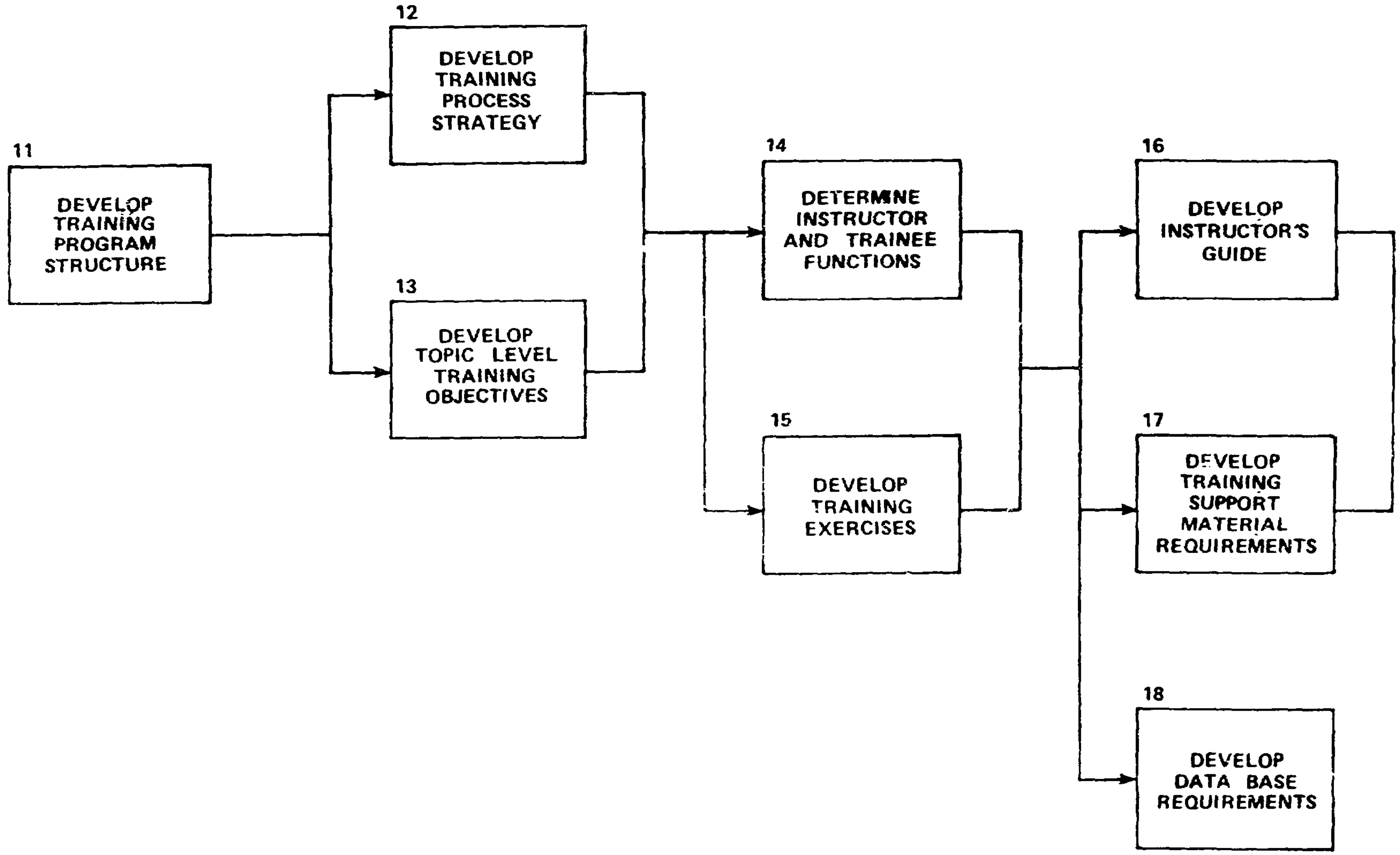

FIGURE G-3. PART II - TRAINING PROGRAM DEVELOPMENT

TABLE G-3. PART II - TASK PRODUCTS

Task	Task Products
11	Set of section level training objectives
11	Time frame and schedule of training program
11	List of instructor qualifications
11	Set of trainee input characteristics
12	Training methodology
12	Description of the mix of classroom and simulator time
12	Information requirements for feedback
12	Set of exercise requirements
13	Topic learning objectives
14	Breakdown of instructor functions
14&15	Breakdown of trainee functions
15	Training exercises, including scenarios (20)
16	Instructor's guide
17	Set of training support material requirements
18	Set of data base requirements

d. Information feedback requirements (type, amount, timing)

e. Exercise requirements (content and number)

This task will be achieved by following accepted training program design practices. The strategy will use advanced training technology and methods where practical in terms of cost and the training situation. Task 13 will be conducted in parallel since both must be developed together.

Task 13. Develop Topic Learning Objectives

The objective is to further refine the section-level training objectives into detailed topic learning objectives.

The topic learning objectives will be developed together with the process strategy. They will specify at a detailed level, the goals of the training program in conformance with the program structure. The conditions under which the objectives will be achieved will also be specified. The topic learning objectives will be developed directly from the section level objectives, and will be done so in regard to the training process strategy. The topic learning objectives should address the skills and knowledge selected in task 2, from the standpoint of the detailed training process. The input and output characteristics (task 11) will affect their development in this regard, by specifying the performance bands within which the objectives should pertain.

Task 14. Determine Instructor and Trainee Functions

The objective is to identify the instructor and trainee functions during training, and to specify characteristics of their respective interfaces.

The specific instructor and trainee functions will be developed in this task, in conjunction with task 15. The trainee will perform functions pertaining to (a) conning of the vessel and (b) training-related analysis. The former will be specified in the development of the exercises. Those trainee functions pertaining to training related analysis will be specified in this task. These functions deal with training-related feedback, instructor cues, test evaluation, and so on. The functions will be inferred from the description of the experimental tasks and the training process.

The instructor's functions are of utmost importance, since they can greatly affect the effectiveness of the training process. They require specification in close coordination with the training process and exercise development. Several factors will be addressed by this analysis:

a. Control over the training process

b. Training methodology and context

c. Training support material (see task 17)

d. Instructor/trainee interface

e. Feedback information and context

Task 15. Develop Training Exercises

The objective is to develop the training exercises for the training program.

The training exercises will be developed in support of the specific topic learning objectives. They will be developed for instruction on the simulator in accordance with the training process strategy. The specific characteristics of the exercises will depend on the experimental design in Part I. They will have to be configured with regard to the particular experimental conditions. The categories of information that will be included are:

a. Training objectives

b. Scenarios (Note: Several scenarios may exist per exercise).

   1. Operational objective and situation description
   2. Geographical area
   3. Environmental conditions
   4. Target and ownship track geometries
   5. Information - input and output
   6. Scenario support material - e.g., weather forecast recordings
   7. Time line history of events
   8. Communication requirements

b. Time line coded

   1. Event
   2. Trainee functions
   3. Instructor functions

c. Performance evaluation criteria

d. Training strategy

   1. Methods to be employed
   2. Information feedback guidelines

Task 16. Develop Instructor's Guide

The objective is to develop a guide for use by the instructor in conducting the training program.

The training program will be conducted in a highly structured fashion to ensure a high degree of control and achieve a high degree of effectiveness. An instructor's guide is an important document in achieving this end. The instructor's guide will provide a detailed outline of the training program, specifying his tasks and the information he needs to accomplish them. The guide will include:

a. Topic level training objectives broken down into exercises across the training program.

b. The training strategy to be followed in achieving each objective, also broken down by exercise.

c. The points to be made by the instructor with supporting information, regarding each objective, as a function of the particular program segment. This will draw upon task 23.

d. The training program schedule broken down by each hour, covering classroom and device time.

e. A description of each exercise, when it should be used, and how to set it up.

f. Identification of the trainee actions to be observed and evaluated during each scenario.

g. Detailed description of the training information feedback to be provided by the instructor.

h. The set of visual aids, primarily classroom.

i. Pre- and post-briefing outlines.

Task 17. Develop Training Support Material Requirements

The objective is to define the characteristics of the supporting material that will be used during the training program.

The training support material consists of those items and capabilities that are necessary aids in conducting the training program. They are anticipated to consist of:

a. Visual aids for classroom presentation

b. Informational summaries of particular effects and ship characteristics (e.g., kick effect) to be passed out to the trainees and discussed

c. Training technology capabilities that must be developed (e.g., real-time strip plots of own ship parameters)

d. Scenario support material (e.g., weather forecasts), and

e. Other instructor or trainee interface capabilities that are necessary (e.g., instructor monitoring of performance measures on the bridge).

The specifications for these materials will be developed during this task. They will consist of outlines identifying the desired characteristics of the various material. They will be detailed to the level required for full development.

These materials will actually be developed in Part III.

Task 18. Develop Data Base Requirements

The objective is to develop the requirements for the visual and radar data bases.

The visual and radar data bases will depend on:

a. The area to be modeled

b. The level of model fidelity required

c. Particular informational characteristics required in the model.

The data base models will depend on the training objectives, the training programs needs, and the performance evaluation needs. These will be investigated to develop an outline of the data base requirements. The data base will be devleoped in task 21.

G.2.3 Part III: Material Development

The material to be used in conducting the Phase 2investigation will be developed in Part III. The requirements and specifications for the material will have been developed during Parts I and II. This part concerns the actual development of material to meet those requirements and specifications.

The Part III tasks are illustrated in FIGURE G-4. Most of the tasks will be conducted in parallel, since they are concerned with different materials. The type and amount of material developed will remain within the level of effort specified for this part. Additional material can be optionally developed, if so decided at a later date, given that appropriate funding is available. The development of supporting material will complete the design portion of the Phase 2 investigation. The Presimulation Report will be developed at this time. The list of Part III task products is presented in TABLE G-4. Each of the tasks is presented in detail below.

Task 19. Select Performance Measures

The objective is to develop the performance measurement algorithms that will be used during the investigation.

A comprehensive set of performance measures have been developed during Phase 1 (see Appendix C). Specific measures to be used during the Phase 2 investigation will be selected from this set and evaluated for their potential and validity. The measures to be used will have two purposes. First, diagnostic performance-related measures will be necessary to generate and provide information feedback during the training process. These measures are needed to delve into the trainee's action, showing him the cause of subsequent shiphandling effects, and illustrating good versus poor performance. The purpose of these measures is to provide training. The second purpose of the performance measures is to enable comparisons to be made between the independent variables. These latter measures need not be used to train. Rather, they should provide a summary measure of performance, for evaluation purposes. These latter measures would be appropriately used in the pre-and post-tests to evaluate the effectiveness of training.

Task 20. Develop Support Software

The objective is to develop the necessary software routines to support the training and analysis functions.

The effort planned for this task will be minimal. Rather, the performance measures, data collection, and analysis routines used during Phase 2 are expected to be drawn from those currently available at the CAORF facility. Minor modifications, however, will be made to those as necessary. Additional development efforts can be optionally decided upon at a later date, if necessary. A description of the optional subtasks follows.

The requirements and characteristics for support software will be developed during Parts I and II. The specific routines will be developed and coded during this task. The routines to be developed and coded are:

a. Performance Measurement Algorithms - These would be implemented in real-time in the SEL computer for calculation during the running of the scenarios. The summary performance measures may, however, be accomplished off-line following the run.

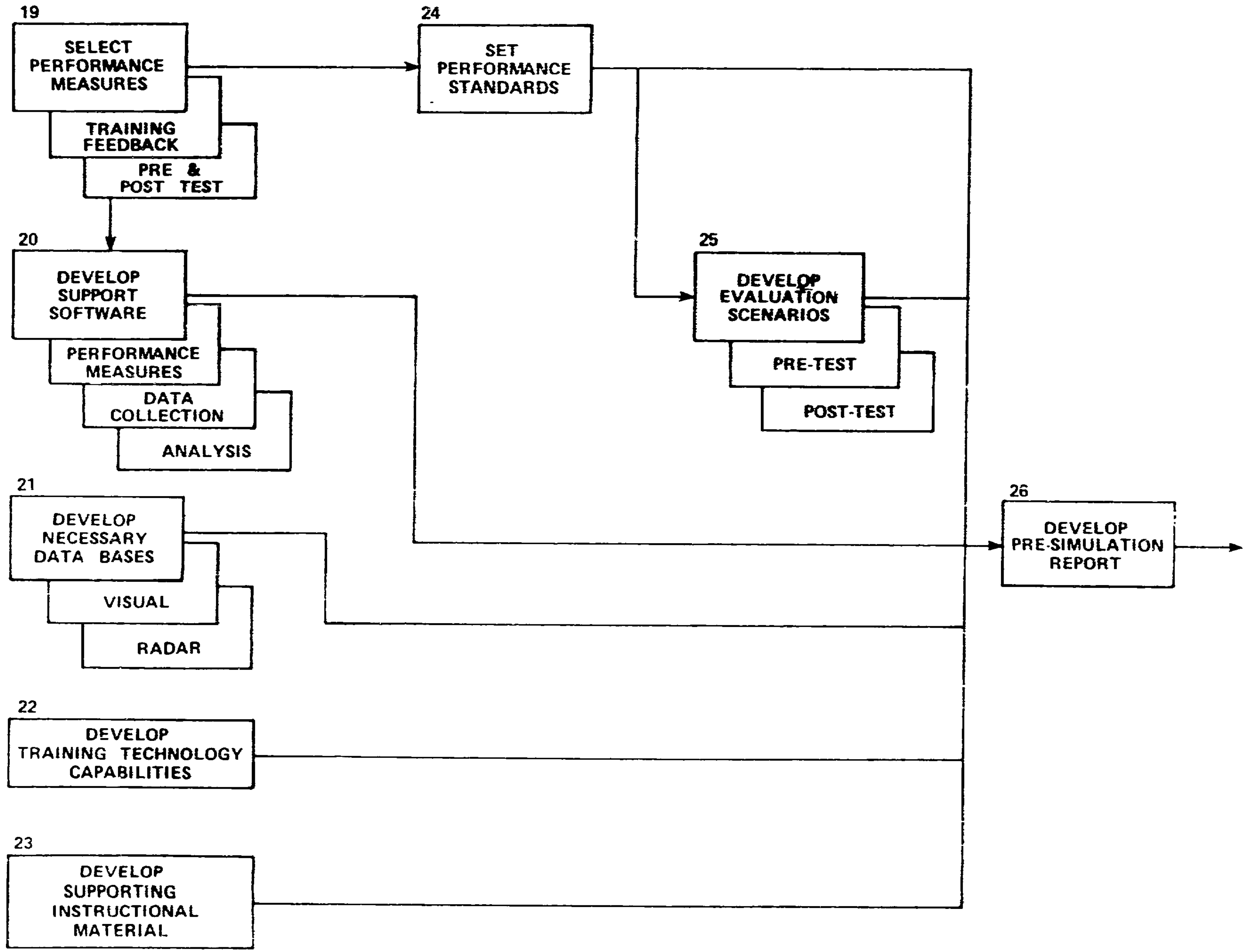

FIGURE G-4. PART III - MATERIAL DEVELOPMENT

TABLE G-4. PART III - TASK PRODUCTS

Task	Task Products
19	Performance measure modifications a. Training b. Performance evaluation
20	Modification of data collection and analysis routines
21	Configuration of visual data base
21	Configuration of radar data base
22	Training technology capabilities
23	Classroom visual aids (200)
23	Information summaries (12)
24	Performance standards (not planned - optional)
25	Pre-test scenario
25	Post-test scenario
26	Presimulator report

b. Data Collection - The capability would be developed in an off-line computer to enter and store information related to performance during each scenario. This will represent the working data file for all analysis. The information, which will have been specified in Tasks 6 and 7, will consist of:

1. Data collected from the run data tape, reduced into an appropriate format

2. Observational data made by the instructor and experimenter, such as task identifications.

c. Analysis Routines - The statistical analysis routines would be put into the off-line computer to operate on the data files of b.2 above. The requirements and specifications for these routines will have been developed in Tasks 6 and 7.

Task 21. Develop Necessary Data Bases

The objective is to develop the visual and radar data bases in accordance with the requirements set-forth in Task 18.

The visual and radar data bases will be developed following the standard modeling practices used at CAORF. The specific data base requirements are not known at this time, but will be developed in task 18.

Consultants will be utilized extensively during this task to evaluate the adequacy of the generated data bases. All of the exercise scenarios will take place within this data base. The evaluation scenarios may also take place within this data base, or may occur within another existing data base, depending on the specific design characteristics specified in Part I.

Task 22. Develop Training Technology Capabilities

The objective is to develop and code the routines necessary to support the required training technology capabilities.

Training technology is currently planned as one of the independent variables for investigation during the project. Particular characteristics will be specified during Task 3 for empirical investigation. The specification of these characteristics may be further modified when the training program is developed in Part II. The specification and development of the training technology capabilities will take place during this task.

The training technology capabilities are planned to include: (a) existing CAORF capabilities and (b) limited additional capabilities. The additional capabilities will be limited to two man-weeks of programmer and analyst development time. Additional developments can be achieved optionally as the need arises and if funds become available. The optional characteristics to be coded will be determined in task 17. They may consist of real-time display of performance-related information on the bridge, or other factors.

Task 23. Develop Supporting Instructional Material

The objective is to develop supporting training material in accordance with the specifications set forth in task 17.

The supporting training material will be developed to achieve the specifications developed in task 17. The material will consist of:

a. Visual aids

b. Information summaries (see task 17).

The visual aids and information summaries will be developed from technical library sources of information.

Task 24. Set Performance Standards

The objective will be to set acceptable performance standards corresponding to the performance measures selected in task 19.

This task is planned only as an option. It is not necessary for the conduct of the training experiment.

Two sets of performance measures will be selected in task 19, diagnostic measures used for training feedback and summary measures used to evaluate and compare performance. Performance standards could be developed for the summary performance measures, since standards are relevant to these. The standards would represent levels of acceptable performance. The performance standards would be set on the basis of:

a. Discussions with knowledgeable individuals - the working group, consultants

b. Running highly experienced individuals on the bridge in representative scenarios

    1. Select and set up representative scenarios

    2. Select highly experienced subjects

    3. Run the test subjects on the simulator

    4. Calculate their performance standards

c. Research literature

The final standards would be based on the above three sources of information.

Task 25. Develop Evaluation Scenarios

The objective is to develop two comprehensive scenarios to evaluate overall performance relating to training effectiveness.

The test scenarios will be developed to evaluate comparative performance. The training exercise scenarios will, presumably, be somewhat narrow, dealing with specific aspects of the shiphandling problem. The progression across the training program will expose the

trainee to all aspects of the program, although each training scenario will be narrow. The evaluation scenarios, on the other hand, will be comprehensive in scope, evaluating all aspects of shiphandling covered by the training program. They will serve as:

a. Measures of training effectiveness - pre- versus post-test, and trained versus untrained on the post-test, and

b. A method for balancing the input skill levels of the trainee/subjects.

The test scenarios will be developed for administration on the simulator. They will be based on the objectives and content of the training program.

Task 26. Develop Presimulation Report

The objective is to develop the Presimulation Report.

The Presimulation Report will be developed at the end of Part III. It will present, in detail, the characteristics of the experimental design (Part I) the training program (Part II), and the material development (Part III). The subsequent two parts of this project will be devoted to collecting and analyzing data.

G.2.4 Part IV: Pre-experimental Evaluation and Modifications

All aspects of the experimental design, including the training program, should be evaluated in a pilot investigation prior to the actual experimental data collection. This serves the purpose of familiarizing the cognizant individuals (e.g., instructor) with the procedures. More importantly it provides an opportunity to evaluate the many elements of the experiment and training program, and make modifications if necessary. The pre-experimental evaluations will take place in Part IV (See FIGURE G-5).

The pre-experimental evaluations will address both the experiment and training program. The training program will be evaluated in a reduced version, since a full-length evaluation would be costly. The Part IV task products are listed in TABLE G-5. Each of the tasks in Part IV is presented below.

Task 27. Design Pre-experimental Runs

The objective is to design the pilot experiment.

The pilot experiment will evaluate the training program and other elements of the experiment. The purpose of the evaluation is to correct deficiencies prior to conducting the experiment. The pre-experimental runs will be configured somewhat differently than the experimental runs to enable a cost-effective evaluation highlighting the most important aspects.

The pre-experimental runs will be designed to evaluate (a) the most important aspects of the experiment, (b) those aspects likely to have the greatest effect on the independent variables, (c) those aspects likely to interfere with the experimental control, and (d) those aspects affecting the experimental design.

This task will identify the primary objectives of the pilot experiment, determine the run configuration and the analysis methods.

Task 28. Schedule Runs

The objective is to set up the pilot experiment run schedule.

The schedule of pre-experimental runs will be established. Arrangements will also be made for the subjects' selection and scheduling.

Task 29. Develop Procedures and Scenarios

The objective is to develop the pilot experiment scenarios and procedures.

The experimental procedures and scenarios that will be used during the experiment will likely require some modification for use in the pilot experiment. This is particularly expected for the training program which will not be administered in its entirety. The experimental procedures and scenarios, including support material, will be modified as necessary to conduct these runs.

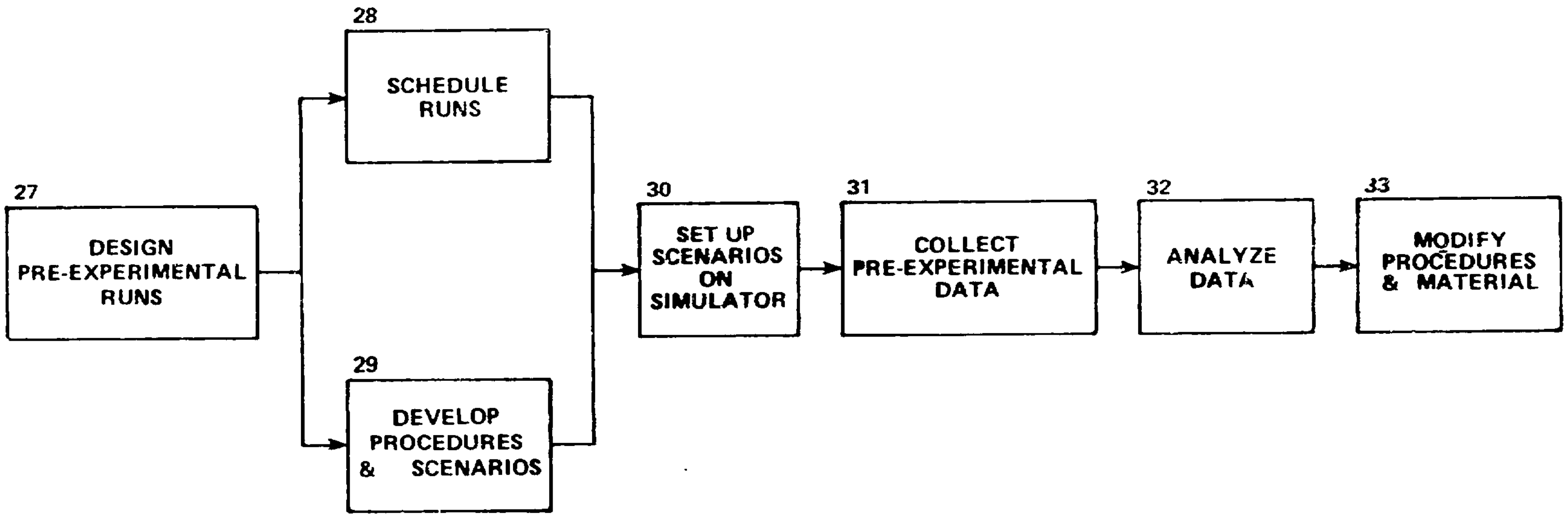

FIGURE G-5. PART IV - PRE-EXPERIMENTAL EVALUATION AND MODIFICATIONS

TABLE G-5. PART IV - TASK PRODUCTS

Task	Task Products
27	Design of pilot experiment
28	Pre-experimental run schedule
29	Pre-experimental run procedures
29	Pre-experimental run support material modifications
30	Pre-experimental scenarios implemented on CAORF
31	Pre-experimental data collected
32	Analysis of pilot data
33	Modified material and procedures

Task 30. Setup Scenarios on Simulator

The objective is to implement the pilot evaluation scenarios on the CAORF simulator.

Until this task, the training and test scenarios will have been developed on paper only. They will be implemented on the simulator during this task, as pertains to the pilot investigations. Two steps are involved in this process. First, the scenario conditions (e.g., own ship start position, target courses, speeds, and maneuver times) must be transcribed into the appropriate setup format and placed on tape. Secondly, the scenarios will have to be run for some time on the simulator to verify their design. This task includes the setting-up, simulator evaluation, and modification of the scenarios.

Task 31. Collect PreExperimental Data

The objective is to collect evaluative data regarding the experimental design and training program.

The pre-experimental runs will be made with a minimum of three subjects. The purpose of these runs is to:

a. Evaluate the training program

b. Evaluate the pre- and post-tests

c. Evaluate the performance measures

d. Evaluate the appropriateness of the independent variables and levels

e. Evaluate the experimental design, procedures, methodology, and material

This task will look at all aspects of the experiment, including the classroom instruction. The data collected is unlikely to contribute to the experimental data base, since the experimental objectives and configuration will be different. These data will be used to evaluate the experiment and direct modifications to improve its effectiveness.

Task 32. Analyze Data

The objective is to analyze the collected data, developing findings regarding the experimental design and training program.

The analytical techniques will have been selected in task 27. The collected data will be analyzed and conclusions drawn regarding the need for modifications. The actual modifications will be made in task 33.

Task 33. Modify Procedures and Materials

The objective is to modify the experimental procedures and material as necessary based on the findings of task 32.

The amount of modification necessary is planned at a minimal level. It is anticipated that some minor modifications will be made to the procedure and material.

G.2.5 Part V: Data Collection and Analysis

Part V represents the culmination of the Phase 2 experiment. The simulator will be set up, data collected, and analyzed, and the final report written during this part (see FIGURE G-6). The experiment will be carried out as planned during parts I through IV. The final report, which will address the long-term plan and Phase III, will detail all aspects of the Phase 2 investigation. The Part V tasks are listed in TABLE G-6.

The Part V tasks are presented below.

Task 34. Coordinate Experimental Logistics

The objective is to coordinate all elements of the experiment.

The logistics of conducting an experiment on CAORF is important due to the complexity and cost. This task will develop the experimental run schedule to achieve efficient use of the simulator. It will also coordinate the various elements of the experiment. These include:

a. Scheduling on-line CAORF time, coordinating the use of the bridge between the different experimental conditions, and with other experiments

b. Obtaining, coordinating, and scheduling subjects

c. Coordinating instructors, data takers, and other personnel as required

The simulator schedule will most likely be sensitive to the experimental conditions, since different simulator configurations will be used. Constraints on changing conditions will have been determined in Parts I and IV. The final schedule of conditions/subjects will reflect these constraints.

Task 35. Set Up Simulator

The objective is to set up the scenarios and other elements of the CAORF simulator operation.

The various elements of simulator operation for the experiment will be set up and tested. Many of these will have been implemented during the preceding pilot investigation. The complete set of experimental materials will be implemented during this task. They will include:

a. Training scenarios

b. Test scenarios

c. Scenario support material (e.g., weather forecasts)

d. Experimental procedures

e. Procedures for controlling and changing experimental conditions

f. Training technology operation

g. Data collection and reduction mechanism

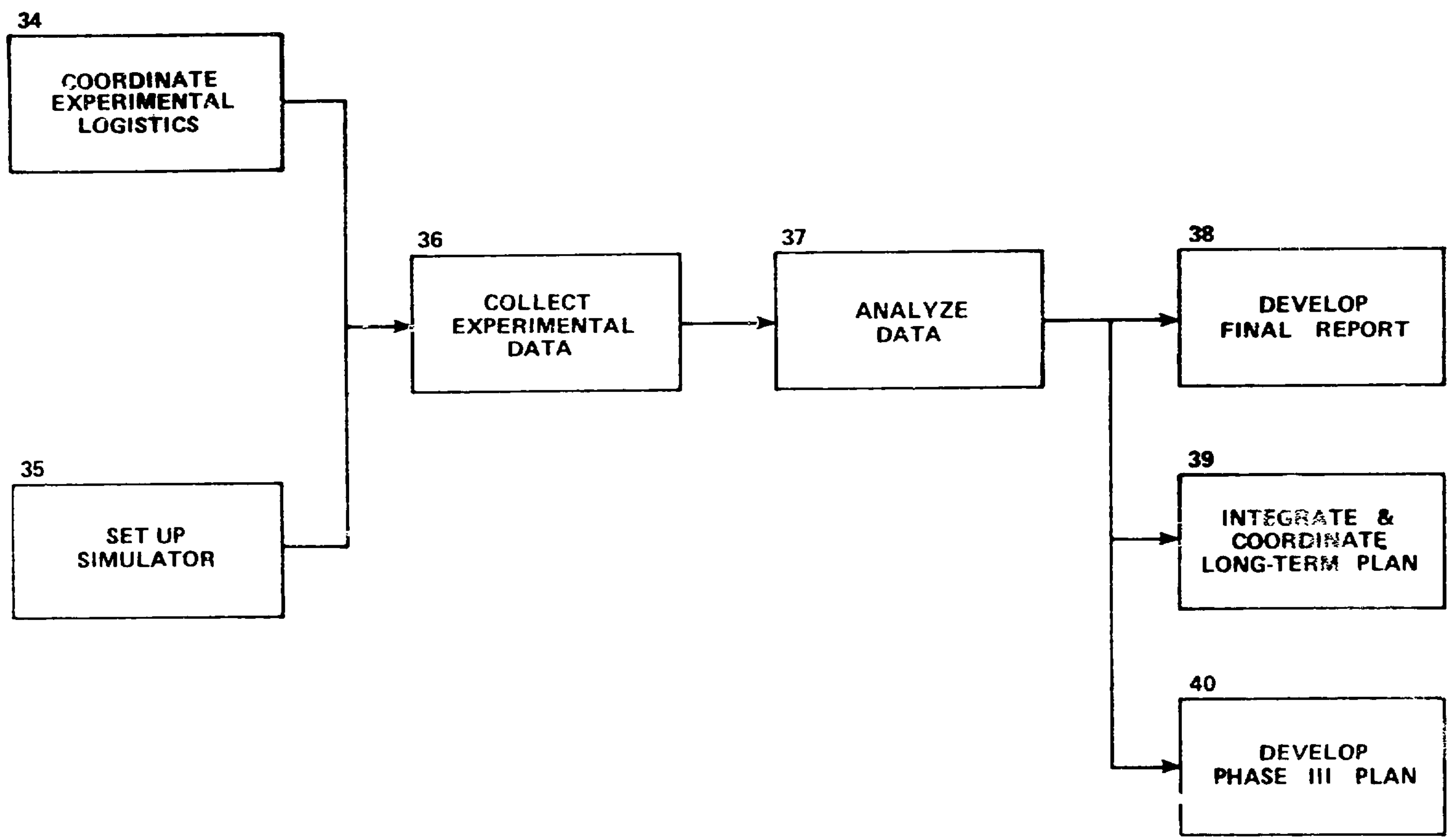

FIGURE G-6. DATA COLLECTION AND ANALYSIS

TABLE G-6. PART V - TASK PRODUCTS

Task	Task Products
34	Experimental run schedule
35	Simulator setup
36	Experimental data collection
37	Analysis of the data
38	Final Report
39	Recommendations to the Long Term Plan
40	Phase III Plan

Tasks 34 and 35 conclude the preparation of the experiment.

Task 36. Collect Experimental Data

The objective is to collect the empirical data via runs on the simulator.

The experimental trials will be i-·plemented and data collected during this task.

Task 37. Analyze Data

The objective is to analytically reduce and evaluate the collected data.

The data anlaysis task will apply statistical techniques to reduce and evaluate the collected data, and to draw conclusions regarding the experimental objectives. Four stages of analysis are planned as follows:

a. Preliminary data reduction after each run. Quick-looks will be made at the data as the experiment progresses to detect problems or other unanticipated findings. This will permit changes in the experiment and/or data collection if necessary.

b. The primary in-depth data analysis. This analysis wi'' ınvestigate the major effects, as planned in Part I. It will concern the experimental models, most likely using the analysis of variance.

c. The secondary level analysis. This analysis will address a variety of other issues in the experiment, also as planned in Part I. These issues will be of secondary importance to those investigated in "b" above.

d. Unplanned analysis. This complex experiment is expected to provide information relevant to a variety of issues that will not have been planned for, but will become evident during collection and analysis of data. An effort will be made to investigate these as time and data permit.

Task 38. Develop Final Report

The objective is to write the final report of Phase II.

The final report will represent the major product of Phase 2. It will recount the experimental design and present the results. More importantly, it will address the impact of the results on the use of simulators for training and licensing. In this regard, the Phase 2 effort will addr^'s the effectiveness of simulator-based training and evaluation as a function of the s rea and other factors. The report will begin the specification of training program a ,te .ce criteria, which will be developed in a later phase. The experimental results will be interpreted together with other findings and information in the literature to begin defining the role of the ship maneuvering simulator. Task 39 will also be reported in the final report, as will Part VI.

Task 39. Integrate and Coordinate Long-Term Plan

This task seeks to update the long-term plan investigating mariner training and licensing.

This task will integrate the findings resulting from Phase 2 into the long-term plan, recommending action as appropriate. The output of this task will be reported in the final report. This will be accomplished via discussion between the USCG, MarAd, and the steering group.

Task 40. Develop Phase III Plan

The objective is to develop the Phase 3 Plan in coordination with the Phase 2 findings and Long-Term Plan.

The Phase 3 Plan will be developed to build toward the long-term objectives. It should be oriented toward the development of a product that would be used in the operational setting (e.g., training program acceptance criteria). The particular objectives will be developed during this task via discussion between the USCG, MarAd, and the steering group.

APPENDIX H

GLOSSARY

A

ability training - training which provides the individual with broad-based skills which can be applied to a variety of different tasks.

atmospherics - conditions which may increase or degrade electronic equipment performance. Usually associated with electrical or thermal abnormalities.

B

brightness - the subjective impression of luminance.

C

collision avoidance system (CAS) - automatic ship contact tracking system. Has the capability of automatically determining contact course, speed and closest point of approach (CPA). Own ship trial maneuvers can be displayed to determine best course for collision avoidance.

computer-generated imagery (CGI) - imagery contained as a program within the computer memory. Computer response to own ship motion is reflected in a continuously updated image display.

contrast - ratio of object brightness to background brightness usually expressed in percent.

control group - a group which is either not trained at all, allowed to be involved in an unstructured training program, or trained within a program which is thought to be inferior to that of the experimental condition.

D

day - visual display condition which includes twilight levels.

deck officer - any licensed deck officer from third mate to captain.

deductive instruction - process of applying a general rule to specific examples.

diagnostic evaluation - an evaluation technique used to determine an individual's specific areas of weakness or strength. This will indicate which areas are to be trained.

E

emergent task situation - that situation for which all tasks and activities cannot be specified and the consequences of certain actions cannot be predicted. Unanticipated situations are prone to emerge.

E

environmental interference - physical disturbance such as wind, rain, sea state or land clutter which may degrade visual or radar performance.

established task situation - situation in which the tasks and activities required have been completely specified.

exercise area - specific geographic scenario limits represented in the training simulator.

experimental group - the group trained within the program structure to be evaluated.

extrinsic feedback - feedback to be supplied by external sources.

F

feedback - any information which follows as a consequence of either a psychological or physiological response.

fidelity - the degree to which the simulator design can portray the natural shipboard environment.

fixed track target control - target motion is constrained by use of predetermined mechanical tracks.

flexible target control - instructor-controlled target motion providing flexibility to meet changing scenario condition.

functional subsystem - a subsystem which performs a specific task (e.g., visual presentation).

H

hardware - components, either actual or simulated, utilized in the design and construction of the major subsystems.

I

individual training - concerned with training skill not involving the coordination of other individuals.

inductive instruction - process of formulating a rule from specific examples.

input characteristics - the relevant skills and knowledge the master is likely to possess prior to entering a simulator-based training program.

inter-organizational validity - the generalizability of a training program developed for one organization relative to its application to the training personnel from a different organization.

interval scale - any scale which possesses the attributes of magnitude and equal intervals, but not an absolute zero point.

I

intra-organizational validity - the training program must allow for specific revisions to meet the demands of changing organizational goals and job components.

intrinsic feedback - feedback supplied automatically by the physiological or psychological systems as a result of come action.

K

knowledge - a clear and certain perception of how to perform a certain task.

L

learning styles - the enhancement of learning under one set of circumstances and the impedence of learning under a different set of circumstances.

luminance - the amount of light flux reflected by a surface to the eye of the observer. Usually expressed in foot-Lamberts.

M

model board - a pre-constructed geographic model representing various fixed exercise areas.

modules - a series of independent learning segments used together for the purpose of training. This type of structure provides for flexibility and variety of use.

monochromatic - single color such as is found in the usual cathode ray tube display.

multichromatic - two or more colors presented in a cathode ray tube display to aid in contact identification.

N

need assessment - the goals and objectives of the training program. The training program must meet the characteristics of the trainee populations.

night - visual display condition which may include light levels permitting the observer to discern ship hull and structure shapes as well as lights.

nomimal scale - the classification of items into discrete groups which do not bear any magnitude relationships to one another.

O

open sea - open sea is (1) where a pilot is not required to be on board; and, (2) where the International Rules of the Road apply.

ordinal scale - any scale which reflects only magnitude and does not possess the attributes of equal intervals or an absolute zero point.

overall relative efficiency value - values assigned to specific characteristic alternatives based on their efficiency in completing the SFOs. This is a relative measure used between alternatives within a given subsystem characteristic.

P

parallel structured task - a task in which the performance of an individual is not dependent upon the performance of his team members.

pelorus - optical instrument used to take bearings on distant objects. Bearing indicator ring is gyro stabilized.

performance measures - measures with which to evaluate the effectiveness of training and tailor the training program to the specific training needs of individuals or groups.

performance validity - the positive transfer of training from the training program to on-the-job performance.

Port XYZ - a hypothetical port which contains services, piloting aids, hazards, various channel configurations, and various environmental factors, all of which could exist in any port.

pre-programmed target control - target motion controlled by internal computer programming or the use of cassette tapes.

probe - TV camera with wide angle lenses used to transmit images from model board installation.

progressive part training - training in which the trainee learns several part tasks, then works on different combinations of the parts until he builds to the total or whole task.

pure part training - training in which the trainee experiences or practices on the several components of the task, one component at a time.

R

radio direction finder (RDF) - electronic equipment used to take bearings from fixed radio shore stations to obtain ship's line of position.

ratio scale - any scale of measurement possessing magnitude, equal intervals, and an absolute zero point.

realism - the ability of a training simulator design to portray conditions found in the natural shipboard environment.

reliability - consistency of a score barring any effects due to training or learning.

resolution - the ability to identify or discriminate between objects. Usually measured in units of minute of arc.

restricted waters - restricted waters generally refers to the confluence areas, pilot waters, harbors, channels, and narrow waterways in which a licensed pilot must be on board the vessel. These areas are subject to VTS control and harbor authorities. In all cases where U.S. inland rules apply, pilots must be on board the vessel and waters are considered restricted.

S

scenario - a comprehensive set of situations which will evaluate the various aspects of shiphandling covered by the training program (i.e., modules).

series structured task - that situation in which performance is based upon all members of the team.

SFOs - specific functional objectives which represent highly detailed shiphandling objectives. They are comprised of two segments: (1) the behavior (i.e., the specific skill and/or knowledge to be attained by the master as a result of training and/or experience) and (2) the conditions which describe the circumstances under which the behavior should be performed.

shiphandling - a term used to represent the broad and diverse tasks performed while conning the vessel (e.g., including fundamental shiphandling, integrated shiphandling, collision avoidance, navigation).

shiphandling (fundamental) - the ability (1) to understand how factors such as vessel displacement, speed, water below the keel, traffic, force and direction of current and wind, and condition of berth affect and restrict a vessel's ability to respond; and (2) to apply this understanding so as to react in a timely manner when presented with various situations.

shiphandling (integrated) - the ability to perform the series of tasks required to successfully accomplish port entry, navigation through the channel, and the approach to a single point mooring, a dock, or an anchorage.

simplified training - the trainee learns on a simplified version of the whole task. An issue of special significance using this method is that of fidelity of the training task.

simulator - a training device designed to train or demonstrate specific skills or knowledge.

part task - a simulator designed to provide training (usually manipulative) in a narrow specific area (e.g., radar, navigation plotting, collision avoidance, and ship plotting).

full bridge - a simulator designed to represent an actual ship as closely as the training objectives require.

simulator limitation - bounds inherent in the nature of the simulator due to the present state of the art.

single bulb image source - projectors which project single spot images.

single point image source - movie or slide projectors which provide a shaped image (e.g., ship hull, navaid, structure, etc.)

skill - having or requiring an ability gained by experience or by a regular program of training.

sound-powered telephone - emergency communication system powered by magnetically generated current stimulated by user's voice independently from any other electrical system.

S

specific training - training which is designed to incorporate only those skills necessary for the learning of a specific task.

T

task analysis - the isolation, compilation, categorization, and examination of all the tasks performed by a master while at sea.

team training - training concerned with the functioning of the team based on the coordination and participation of all or several individuals.

training control - the capability of regulating various factors at will to suit any training condition without having to deal with the restraints imposed by extraneous forces (e.g., weather and visibility).

training process strategy - the detailed methodology pertaining to the mix of classroom and simulator training exercise design, timing, and content of feedback provided during training, and input and output characteristics.

training program guidelines - the framework within which the simulator training can and should be accomplished. The guidelines address the alternative strategies, training objectives, and performance measures and standards.

training program structure - the macro-level training framework, consisting of the scheduling and use of course, part and whole task simulators, and training material.

training specification - the context and the methodological alternatives to achieve each SFO and to further specify the informational requirements necessary to support such training.

training support material - visual aids, hand-out documents, scenarios, feedback displays and charts, etc.

training validity - the establishment of treatment effects as a result of the training program.

transfer of training - the transfer of learned behavior to other relevant stimulus situations not encountered during training.

V

validity - the capacity of a training program to actually develop the skills and behavior for which it was designed.

W

walkie-talkie - hand-held radio transceiver used for short range communication.

whole task - training in which the trainee learns all of the components of the complete task and does not train on any fraction of the whole or total task.

APPENDIX I

REFERENCES

Aagard, J.A. and Braby, R. Learning Guidelines and Algorithms for Types of Training Objectives, TAEG Report No. 23, Orlando, Florida: Training Analysis and Evaluation Group, March 1976.

Ahlers, R.H., Jr. Preliminary Investigations Concerning the Training of Tactical Decision Making Behavior, IH-269, Orlando, Florida: Human Factors Laboratory, Naval Training Equipment Center, July 1976.

Air Carriers and Commercial Operators of Large Aircraft, Part 121, Title 14, Code of Federal Regulations, 1976.

Angell, D., Shearer, J., and Berliner, D. Study of Training Performance Evaluation Techniques, NAVTRADEVCEN 1449-1, Orlando, Florida: Naval Training Device Center, October 1964.

Annett, J. The Role of Knowledge of Results in Learning: A Survey (NAVTRADEVCEN Tech. Rep. #342-3) Orlando, Florida: Naval Training Device Center, May 1961.

Annual Report. The Liverpool Underwriters Association, 1977.

Augenti, B.J. Human Factors and Simulation Training, Linthicum Heights, Maryland: National Transportation Apprenticeship and Training Conference, April 16-18, 1974.

Bartley, S.H. Principles of Perception, Harper and Brothers, 1958.

Betz, N.E. and Weiss, D.J. Psychological Effects of Immediate Knowledge of Results and Adaptive Ability Testing, Research Report 76-4, Department of Psychology, University of Minnesota, June 1976.

Biersner, R.J. Observations on the Use and Evaluation of ECII-LP Simulators for Aviation Training, CNETS Report 2-76, Washington, D.C.: The Chief of Naval Education and Training Support, October 1976.

Biersner, R.J. Social Factors and Training Effectiveness: The Affective Domain Revisited, NAVTRAEQUIPCEN IH-275, Orlando, Florida: Naval Training Equipment Center, 1975.

Birmingham, H.P., Kahn, A., Taylor, F.V. A Demonstration of the Effects of Quickening in a Multiple-Coordinated Control Task, NRL Report No. 4380, Naval Research Lab, Washington, D.C., June 1954.

Bishop, H.P. Hardware Parameters Related to Operator Training Capabilities, HumRRO Professional Paper 9-71, Alexandria, Virginia: Human Resources Research Organization, June 1971.

Blaiwes, A.S., Puig, J.A., and Regan, J.J. "Transfer of Training and the Measurement of Training Effectiveness," Human Factors, 1973 (15)(6), 525-533.

Blaiwes, A.S. and Regan, J.J. An Integrated Approach to the Study of Learning, Retention, and Transfer -- A Key Issue in Training Device Research and Development, Orlando, Florida: Technical Report IH-178, 1970.

Blaiwes, A.S. and Weller, D.R. New Approaches to Social Instruction, NAVTRAEQUIPCEN IH-275, Orlando, Florida: Naval Training Equipment Center, 1975.

Braby, R. et al. A Technique for Choosing Cost-Effective Instructional Delivery Systems, TAEG Report No. 16, Orlando, Florida: Training Analysis and Evaluation Group, April 1975.

Briggs, G.E. and Johnston, W.A. Laboratory Research on Team Training, (NAVTRADEVCEN Tech. Rep. #1327-3) Port Washington, New York: Naval Training Device Center, 1966.

Briggs, G.E. and Johnston, W.A. Team Training (NAVTRADEVCEN, Tech. Rep. #1327-4) Orlando, Florida; Naval Training Device Center, 1967.

Briggs, G.E. and Naylor, J.C. Experiments on Team Training in a CIC-type Task Environment, (NAVTRADEVCEN 1327-1) Orlando, Florida: Naval Training Device Center, June 1964.

Briggs, G.E., Naylor, J.C.,and Fuchs, A.H. Whole Versus Part Training as a Function of Task Dimensions, (NAVTRADEVCEN 950-2) Naval Training Device Center, Port Washington, New York: February 1962.

Brock, J.F. Development of Two Models for Improvement of a Combat Information Center Watch Officer Course: A Proposal for Implementation, Research Memorandum SRM 73-1, San Diego, California: Naval Personnel and Training Research Laboratory 1972.

Brock, J.F. Instructional Design Making in the Design of Operator Training: An Eclectic Model, NPRDC-TR-77-31, San Diego, California: Navy Personnel Research and Development Center, May 1977.

Brummer, G.M.A., and van Wijk, W.R. The Ship Manoeuvering and Research Simulator of the Institute TNO for Mechanical Constructions, Delft, Netherlands, September 1970.

Callan, J.R., Kelly, R.T., and Wicotra, A. Measuring Submarine Approach Officer Performance on the 21A40 Trainer: Instrumentation and Preliminary Results, NPRDC-TR-78-9, San Diego, California: Navy Personnel Research and Development Center, 1978.

CAORF Operational Exercises, National Maritime Research Center, Kings Point, New York.

Caro, P. Some Current Problems in Simulator Design, Testing, and Use, HumRRO Professional Paper 2-77, Alexandria, Virginia: Human Resources Research Organization, March 1977.

Caro, P. Some Factors Influencing Air Force Simulator Training Effectiveness, HumRRO Technical Report 77-2, Alexandria, Virginia: Human Resources Research Organization, March 1977.

Carpenter, M.H. and Huffner, J.R. Pilot Decision Making While Maneuvering Ships in Confined Waters, Maritime Institute of Technology and Graduate Studies, Linthicum, Maryland, February 1977.

Charles, J.P., Johnson, R.M., and Swink, J.R. Automatic Flight Training (AFT) GCI/CIC Air Attack, NAVTRAEQUIPCEN 72-C-0108-1, Orlando, Florida: Naval Training Equipment Center, November 1973.

Chenzoff, A.P. and Folley, J.D. Guidelines for Training Situation Analysis, NAVTRADEVCEN 1218-4, 1965.

Chesler, D. Application and Utilization of Training Aids and Devices: Simulated Exercises Trainee Performance Evaluation, Research Report SRR 73-7, San Diego, California: Naval Personnel and Training Research Laboratory, September 1972.

Chesler, D. Computer-Assisted Performance Evaluation for Navy Anti-Air Warfare Training: Concepts, Methods, and Constraints, Research Report 71-25, San Diego, California: Naval Personnel and Training Research Laboratory, May 1971.

Cockrell, J.T. and Sadacca, R. Training Individual Interpreters Using Team Consensus Feedback, Technical Research Report 1171, Washington, D.C., U. S. Army Behavior and Systems Research Laboratory, 1971.

Collins, A. Processes in Acquiring Knowledge, BBN Report No. 3231, Cambridge, Massachusetts: Bolt, Beranek and Newman, Inc., January 1976.

Cordell, C.C. and Nutter, R.V. Ship Handling and Ship Handling Training, TAEG Report No. 41, December 1976.

Corso, J.E. The Experimental Psychology of Sensory Behavior, Holt, Rinehart and Winston, 1967.

Crawford, A.M. et al. Low Cost Part-Task Training Using Interactive Computer Graphics for Simulation of Operational Equipment, NPRDC TR 76TQ-46, San Diego, California: Navy Personnel Research and Development Center, September 1976.

Crawford, M.P. "Dimensions of Simulation," American Psychologist, Vol. 21(8), August 1966, pp. 788-796.

Crawford, M.P. Simulation in Training and Education, HumRRO Professional Paper 40-67, Alexandria, Virginia: Human Resources Research Organization, September 1967.

Cream, F.T., Eggemeier, T. and Klein, G.A. "A Strategy for the Development of Training Devices," Human Factors 1978, 20, 145-158.

Daniels, R.W. and Alden, D. G. The Feasibility of Generalized Acoustic Sensor Operating Training, NAVTRAEQUIPCEN N-61339-74-C-0067, Orlando, Florida: Naval Training Equipment Center, May 1975.

Daniels, R.W. et al. Automated Operator Instruction in Team Tactics, NAVTRADEVCEN 70-C-0310-1, Naval Training Device Center, Orlando, Florida: January 1972.

Duncan, C.P. "Transfer After Training With Single Versus Multiple Tasks," Journal of Experimental Psychology, 1958, 55, 63-72.

REFERENCES (CONT'D)

Edmonds, E.M., Selby, H.E. and Meuller, M.R. "Learning How to Learn Schemata," Psychonomic Science, 1966, 6, (4) 177-178.

Evans, S.H. "A Brief Statement of Schema Theory," Psychonomic Science, 1967, 8 (2), 87-88.

Exercise Controller's Guide, Submarine Ocean Acoustic Trainer, Vol. I, New London, Connecticut: U.S. Naval Underwater Systems Center, March 1, 1977.

Farrell and Booth, Design Handbook for Imagery Interpretation Equipment.

Fleishman. E.A. and Ellison, G.A. "Prediction of Transfer and Other Learning Phenomena From Ability and Personality Measures," Journal of Educational Psychology, 1969, 60, 300-314.

Fleishman, E.A. "On the Relation Between Abilities, Learning and Human Performance," American Psychologist, November 1972, 1017-1032.

Folley, J.D. "Analyzing the Training Problem," NTDC 25th Anniversary Commemorative Technical Journal, 1971.

Ford, W.R. Self-Limited and Unlimited Word Usage During Problem Solving in Two Telecommunication Modes, Technical Report No. 7, Johns Hopkins University, 1977.

Future of Simulators in Skills Training, First International Learning Technology Congress and Exposition on Applied Learning Technology Proceedings, Vol. IV, Washington, D.C.: Society for Applied Learning Technology, July 21-23, 1976.

Gagne, R.M. The Conditions of Learning, Holt, Rinehart and Winston, Inc., August 1966.

Gebhard, J.W. Detection of New Targets on a Cathode Ray Tube (PPI Presentation) With and Without an Associated Auditory Signal, Systems Research Field Laboratory, Johns Hopkins University, Memorandum Rep. No. 166-1-10, 1947.

Gentner, D.R. and Norman, D.A. The Flow Tutor: Schemes for Tutoring, Report No. 7702, San Diego, California: University of California, 1977.

Gerathewohl, S.G. Fidelity of Simulation and Transfer of Training: A Review of the Problem: AM 69-23, Washington, D.C.: Department of Transportation, Federal Aviation Administration, December 1969.

Goldstein, I.L. "The Pursuit of Validity in the Evaluation of Training Programs," Human Factors, 1978, 20, 131-144.

Goldstein, I.L. Training Program Development and Evaluation, Monterey, California: Brooks/Cole 1974.

Grimsley, D.L. Acquisition, Retention, and Retraining Group Studies on Using Low-Fidelity Training Devices, HumRRO Technical Report 69-4, Alexandria, Virginia: Human Resources Research Organization, March 1969.

Gropentin, H. Possibilities for Solving Visual Problems in Navigation and Ship Simulators. VFW-Fokker/Marsem 1978.

Gropper, G.P. Instructional Strategies, Englewood Cliffs, New Jersey: Educational Technology Publications, 1974.

Gross, M.J. Personnel Training for Commercial Nuclear Propulsion, Seminar on Commercial Applications of Nuclear Propulsion, U.S. Merchant Marine Academy, 1973.

Grove, N. "Gains that Move the World's Oil Superships," in National Geographic, Vol. 154, No. 1, July 1978, pg. 102-124.

Hall, E.R. and Rizzo, W.A. An Assessment of U.S. Navy Tactical Team Training TAEG Report No. 18, Orlando, Florida: Training Analysis and Evaluation Group, March 1975.

Hammell, T.J., Gasteyer, C.E., and Pesch, A.J. Advanced Officer Tactics Training Device Needs and Performance Measurement Technique, Vol. I of II, NAVTRAEQUIPCEN 72-C-0053-1, Orlando, Florida: Naval Training Equipment Center, November 1973.

Hammell, T.J. and Mara, T.D. Final Report - Application of Decision-Making and Team Training Research to Operational Training: A Translative Technique, NAVTRADEVCEN 68-C-0242-1, Orlando, Florida: Naval Training Device Center, April 1970.

Hammell, T.J. et al. Prototype Tactical Decision-Making Training System - Development Summary, NAVTRAEQUIPCEN 75-C-0078-1, Orlando, Florida: Naval Training Equipment Center, February 1976.

Hammell, T.J., Sroka, F.P., and Allen, F.L. Study of Training Device Needs for Meeting Basic Officer Tactics Training Requirements, Vol. I of II, NAVTRADEVCEN 69-C-0140-1, Orlando, Florida: Naval Training Device Center, 1971.

Hausser, D. et al. Application of Computer-Assisted Instruction to Interpersonal Skill Training, NAVTRAEQUIPCEN 74-C-0100-1, Orlando, Florida: Naval Training Equipment Center, January 1976.

Heintzman, R.J. "An Air Transportable Programmable Air-to-Air Combat Simulation," 9th NTEC/Industry Conference Proceedings, Orlando, Florida: November 9-11, 1976, pp. 49-52.

Henkel, M. Capt. and Willms, C. Capt. Bremen Nautical Academy Ship Handling Simulator, Introduction and Exercise Curriculum, West Germany, September 1975.

Hick, W.E. and Bates, J.A.V. The Human Operator of Control Mechanisms, Report No. 17-204, Permanent Records of Research and Development, U.K. Ministry of Supply, London, England (225).

Hilgard, E.R. and Bower, G.H. Theories of Learning (3rd ed.) New York: Appleton-Century Crofts, 1966.

Hinton, W.M., Jr., and Fishburne, R.P., Jr. "Performance Oriented Aircrew Training: Optimization Through ISD," 9th NTEC/Industry Conference Proceedings, Orlando, Florida: November 9-11, 1976, pp. 173-178.

Hochberg, J.H. Perception, Foundation of Modern Psychology Series, Prentice Hall, 1964.

Hogan, J.C. Trainability of Abilities: A Review of Nonspecific Transfer Issues Relevant to Ability Training. (ARRO-R 78-1) Washington, D.C.: Advanced Research Resources Organization, January 1978.

Hogan, J.C. Trainability of Abilities: A Review of Nonspecific Transfer Issues Relevant to Ability Training, Technical Report ARRO-3010-TRI, Washington, D.C.: Advanced Research Resources Organization, 1978.

Hooft, J.P., Keith, V.F. and Porricelli, J.D. The Influence of Human Behavior on the Controllability of Ships, Fourth International Symposium on Transport of Hazardous Cargos at Sea and Inland Waterways, Jacksonville, 1975.

Horrocks, J.E., Heermann, E. and Krug, R.E. Team Training III: An Approach of Optimum Methods and Procedures (NAVTRADEVCEN 198-3) Port Washington, New York: Naval Training Device Center, August 1961.

Huffner, J.R. Pilotage in Confined Waterways of the United States: A Preliminary Study of Pilot Decision-Making, USCG-D-96-76, Linthicum, Maryland: Maritime Institute of Technology and Graduate Studies, July 1976.

Hughes, T.E.C. and O'Halloran, J.T. "The Use of Simulation in the Training of Nuclear Power Plant Operators," NTEC/Industry Conference Proceedings, 1974.

Ince, F., Williges, R.C., and Roscoe, S.N. "Aircraft Simulator Motion and the Order of Merit of Flight Attitude and Steering Guidance Displays," Human Factors, Vol. 17(4), 1975, pp. 388-400.

Instructor's Handbook for Advanced Submerged Control Training, Device 21C5, Vol. I, NAVTRADEVCEN P-3489, Orlando, Florida: Naval Training Device Center, 1969.

Inter-Governmental Maritime Consultative Organization (IMCO), International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers, July 1978.

Inter-Governmental Maritime Consultative Organization (IMCO), Proposed Standards of Training and Watchkeeping in (STW X/7) Sub-Committee on Standards of Training and Watchkeeping, 10th Session, 19-23 September 1977.

International Association of Ports and Harbors, Special Committee on Large Ships, Final Report, September 1976.

Jeantheau, G.G. and Andersen, B.G. Training System Use and Effectiveness Evaluation. (NAVTRADEVCEN 1743-1) Orlando, Florida: Naval Training Device Center, July 1966.

REFERENCES (CONT'D)

Jeantheau, G.G. Handbook for Training Systems Evaluation (U), NAVTRADEVCEN 66-C-0013-1, Orlando, Florida: Naval Training Device Center, November 1970.

Jones, R. Capt. and Plant, R.M. Study Guide to Multiple Choice Examinations for Chief Mate and Master, Cornell Maritime Press, Inc., Cambridge, Maryland, 1976.

Kanarick, A.F., Alden, D.G. and Daniels, R.W. "Decision-Making and Team Training in Complex Tactical Training Systems of the Future," Naval Training Device Center 25th Anniversary Commemorative Technical Journal, November 1977.

Kaufman, L. An Introduction to Visual Perception, Sight and Mind. Oxford University Press, 1974.

Kelly, C.R. Predictor Instruments Look to the Future, Control Engineering, March 1962.

Kelly, C.R., Mitcheli, M.B., Wargo, M.J. and Prosin, D.J. The Role of Prediction in Training With a Simulated Orbital Docking Task. (NAVTRADEVCEN-1767) Naval Training Device Center: June 1966.

Kelly, C.R. and Wargo, M.J. Adaptive Techniques for Synthetic Flight Training Systems. (NAVTRADEVCEN 68-C-0136-1), Orlando, Florida: Naval Training Device Center: October 1968.

King, W. and Duva, J.S. Editors, New Concepts in Maintenance Trainers and Performance Aids, NAVTRAEQUIPCEN IH-255, Orlando, Florida: Naval Training Equipment Center, October 1975.

Klaus, D.J. and Glaser, R. Reinforcement Determinants of Team Proficiency, Organizational Behavior and Human Performance, 1970.

Klemmer, E.T. "Time Uncertainty in Simple Reaction Time," Journal Experimental Psychology, 51, 179 (232) 1956.

Kribs, H.D., Thurmond, P., and Mark, L. Computerized Collective Training for Teams, ARI Technical Report TR-77-A4, Arlington, Virginia: U.S. Army Research Institute, February 1977.

Krueger, G.P. Conferencing and Teleconferencing in Three Communication Modes as a Function of the Number of Conferees, Technical Report No. 6, John Hopkins University, 1977.

Krumboltz, J.D. and Yabroff, W.W. "The Comparative Effects of Inductive and Deductive Sequences in Programmed Instruction," American Educational Research Journal, 1965, 2, 223-236.

Krumm, R.L. and Farina, A.J. Effectiveness of Integrated Flight Simulator Training in Promoting B-52 Crew Coordination, (MRL Technical Documentary Report 62-1) Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratories, Feb. 1962.

Krumm, R.L. and Buffardi, L. Training Effectiveness Evaluation of Naval Training Devices, Part I: A Study of Submarine Diving Trainer Effectiveness, NAVTRADEVCEN 69-C-0322-1, Orlando, Florida: Naval Training Device Center, December.

Laabs, G.J., Panell, R.C., and Pickering, E.J. A Personnel Readiness Training Program: Maintenance of the Missile Test and Readiness Equipment (MTRE MK7 MOD 2), TR 77-19, San Diego, California: Navy Personnel Research and Development Center, March 1977.

Lamb, J.C., Bertsche, W.R., and Carey, B.G. A Study of a Generalized Submarine Advanced Casualty Ship Control Training Device, Vol. I and II, NAVTRADEVCEN 69-C-0117-1, Orlando, Florida: Naval Training Device Center, 1970.

Larson, O.A., Sander, S.I., and Steinemann, J.H. Survey of Unit Performance Effectiveness Measures, NPRDC Report No. TR-74-11, San Diego, California: Navy Personnel Research and Development Center, January 1974.

Leonard, J.A. The Effect of Partial Advance Information, Report APU-217/54, Applied Psychology Research Unit, Medical Research Council, Cambridge, England (232), 1954.

Lindahl, W.H. and Gardner, J.H. Application of Simulation to Individualized Self-Paced Training, TAEG Report No. 11-2, Orlando, Florida: Training Analysis and Evaluation Groups, September 1974.

Lutz, K.A. and Rigney, J.W. The Effects of Student-Generated Elaboration During Acquisition of Concepts in Science, Technical Report No. 82, University of Southern California.

Lyons, J.D. Technology of Training Project Impact, HumRRO Professional Paper 21-70, Alexandria, Virginia: Human Resources Research Organization, June 1970.

Mackie, R.R. et al. Factors Leading to the Acceptance or Rejection of Training Devices, NAVTRAEQUIPCEN 70-C-0276-1, Orlando, Florida: Naval Training Equipment Center, August 1972.

Mara, T.D. Final Report: Human Factors in Ship Control, Vol. I, II, and III, General Dynamics, Groton, Connecticut, January 6, 1968.

Mara, T.D. and Pollack, M. Toward a Cockpit Design: Using CAORF to Modify the Traditional Wheelhouse, Proceedings of the 2nd IFAC/IFIP Symposium, 1976.

Marconi Radar Systems Limited, Simulation Systems, A GEC-Marconi Electronics Company, New Parks, Leicester, England.

Maritime Transportation Research Board, Panel on Human Error in Merchant Safety, Washington, D.C. 1976.

Marsim '78, First International Conference on Marine Simulation. The College of Nautical Studies, Southampton. September 5-8, 1978.

McClelland, W.A. Individualized Training and the Training of Individuals, HumRRO Professional Paper 24-71, Alexandria, Virginia: Human Resources Research Organization, July 1971.

McCluskey, M.R. Perspectives on Simulation and Miniaturization, HumRRO Professional Paper 14-72, Alexandria, Virginia: Human Resources Research Organization, October 1971.

McCormick, E.J. Human Factors in Engineering and Design, McGraw-Hill Book Company, 1976.

McCutcheon, R.E. and Brock, J.F. Effects of Establishing a Conceptualization Context for Learning, Monitoring, and Evaluating Tasks, NPRL Research Report 72-4, San Diego, California: Naval Personnel and Training Research Laboratory, 1971.

McFann, H.H. and Heyl, A.A. Individual Training of Personnel of Different Attitudes, HumRRO Research in Training Technology Professional Paper 21-70, Alexandria, Virginia: Human Resources Research Organization, June 1970.

Meister and Sullivan, Guide to Human Engineering Design for Visual Display, Engineering Psychology Branch, Office of Naval Research, August 1969.

Meister, D., Sullivan, D., Thompson, E.A., and Finley, D.L. Training Effectiveness Evaluation of Naval Training Devices, Part II. A Study of Device 2F66A (S-2E Trainer) Effectiveness. Orlando, Florida: Technical Report NAVTRADEVCEN 69-C-0322-2, 1971.

Mengelkoch, R.F., Adams, J.A., and Gainer, C.A. "The Forgetting of Instrument Flying Skills," Human Factors, Vol. 13 (5), 1971, pp. 397-405.

Merrill, M.D. "Necessary Psychological Conditions for Defining Instructional Outcome," Educational Technology, August 1971, pp. 34-39.

Merrill, M.D. and Tennyson, R.D. "Hierarchical Models in the Development of a Theory of Instruction: A Comparison of Bloom, Gagne and Merrill," Educational Technology, September 1971, pp. 27-31.

Message to Congress, President Jimmy Carter, Subject: "Merchant Marine Safety and Pollution," March 18, 1977.

Mew, D.V. Optimization of Training for Marginal Personnel, NAVTRAEQUIPCEN IH-240, Orlando, Florida: Naval Training Equipment Center, 1974.

Meyer, D.E. et al. A Study of Simulator Capabilities in an Operational Training Program, AMRL-TR-67-14, Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratories, May 1967.

Micheli, G.S. Analysis of the Transfer of Training, Substitution, and Fidelity of Simulation of Transfer of Equipment, TAEG Report No. 2, Orlando, Florida: Training and Evaluation Group, 1972.

Micheli, G.S. Augmenting Feedback and Transfer of Training (NAVTRADEVCEN Tech. Report 111-41) Orlando, Florida: Naval Training Device Center, March 1966.

Micheli, G.S. and Puig, J.A. Training Systems Effectiveness Evaluations. Orlando, Florida: Unpublished Report NAVTRAEQUIPCEN, 1972.

Miller, C.G. Some Considerations in the Design and Utilization of Simulators for Training, AFHRL-TR-74-65, Lowry Air Force Base, Colorado: Air Force Human Resources Laboratory, August 1974.

Miller, R.B. Handbook of Training and Training Equipment Design. Wright Air Development Center. Tech. Report 53-136, 1953.

REFERENCES (Cont'D)

Montmerlo, M.D. and Tennyson, M.E. Instructional Systems Development: Conceptual Analysis and Comprehensive Bibliography, NTEC IH-257, Orlando, Florida: Naval Training Equipment Center, February 1976.

Morgan, C.T. Introduction to Psychology, McGraw-Hill, 1961.

Morrisett, L.J. and Horland, C.I. "A Comparison of Three Variables of Training in Human Problem Solving," Journal of Experimental Psychology, 1959, 58.

National Transportation Safety Board, Safety Record of the U.S. Scheduled Airlines, 1938 through 1970.

Naval Training Device Center 25th Anniversary Commemorative Technical Journal, November 1971.

Navigation Simulator in Tokyo University of Mercantile Marine, Japan.

Navigation and Vessel Inspection, Enclosures (2) and (3) to Circular 7-65, Change 1, International Rules of the Road.

Naylor, J.C. Parameters Affecting the Relative Efficiency of Part and Whole Practice Methods: A Review of the Literature (NAVTRADEVCEN 950-1) Naval Training Device Center, Port Washington, New York: 1962.

Neches, R. Intelligent Educational Dialogue Systems, Report No. 7701, San Diego, California: University of California 1977.

Nickerson, R.S. and Feehrer, C.E. Decision-Making and Training: A Review of Theoretical and Empirical Studies of Decision-Making and Their Implications for the Training of Decision Makers, NAVTRAEQUIPCEN 73-C-0128-1, Orlando, Florida: Naval Training Equipment Center, August 1975.

Northeast Nuclear Energy Company, Secondary Plant Operators Training Manual, (for Millstone Nuclear Power Station, Waterford, Connecticut), November 15, 1977.

7th NTEC/Industry Conference Proceedings, November 19-21, 1974.

8th NTEC/Industry Conference Proceedings, November 18-20, 1975.

9th NTEC/Industry Conference Proceedings, November 9-11, 1976.

Ontiveros, R.J. Capabilities, Necessary Characteristics and Effectiveness of Pilot Ground Trainers. Phase II, Visual Reference Flight Maneuvers, FAA-RD-73-108, Atlantic City, New Jersey: Federal Aviation Administration, August 1973.

Ozkapton, H. Critical Visual Requirements for NOE Flight Research, 8th NTEC/Industry Conference Proceedings, 1975.

Payman, S.P. and Witt, F.G.W. Some Aspects of the Acquisition of Skill in Controlling Ships, Paper presented at the Symposium on Marine Transportation Systems, The Hague, 1976.

Pesch, A.J. and Hammell, T.J. Basic and Advanced Submarine Officer's Tactical Training Device Requirements (Executive Summary), NAVTRAEQUIPCEN 72-C-0053-1 (A), Orlando, Florida: Naval Training Equipment Center, April 1974.

Pesch, A.J. Hammell, T.J., and Ewalt, F.M. Tactical Decision-Making Training System Design, NAVTRAEQUIPCEN 73-C-0158-1, Orlando, Florida: Naval Training Equipment Center, November 1974.

Pesch, A.J., Hammell, T.J., and Lane, W.P. Computer Simulation for Command and Control Training System, NAVTRAEQUIPCEN IH-240, Orlando, Florida: Naval Training Equipment Center, 1974.

Pickering, E.J. and Anderson, A.V. Measurement of Job-Performance Capabilities, NPRDC TR-77-6, San Diego, California: Navy Personnel Research and Development Center, 1976.

Pieper, W.J., Folley, J.D., Jr., and Chenzoff, A.P. Learner-Centered Instruction (LCI): Vol. III, Plan of Instruction, AMRL-TR-68-116, Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratories, October 1968.

Port Revel Marine Research and Training Center (Operated by Sogreah), Shiphandling, Reference Manual, Port Revel, 38136, Saint Pierre de Bressieux, France.

Postman, L. and Schwartz, M. "Studies of Learning to Learn, I: Transfer as a Function of Method of Practice and Class of Verbal Materials," Journal of Verbal Learning and Verbal Behavior, 1964, 3 37-49.

Potempa, K.W., Lintz, L.M., and Luckew, R.S. "Impact of Avionic Design Characteristics on Technical Training Requirement and Job Performance," Human Factors, Vol. 17(1), 1975, pp. 13-24.

Povenmire, H.K. and Roscoe, S.N. "An Evaluation of Ground-Based Flight Trainers in Routine Primary Flight Training," Human Factors, Vol. 13(2), 1971, pp. 109-116.

Prophet, W.W. and Boyd, H.A. Device-Task Fidelity and Transfer of Training: Aircraft Cockpit Procedure Training, HumRRO Technical Report 70-10, Alexandria, Virginia: Human Resources Research Organization, July 1970.

Prophet, W.W., Caro, P.W., and Hall, E.R. Some Current Issues in the Design of Flight Training Devices, HumRRO Professional Paper 5-72, Alexandria, Virginia: Human Resources Research Organization, 1972.

Prophet, W.W. Synthetic Flight Training Devices, HumRRO Research in Training Technology Professional Paper 21-70, Alexandria, Virginia: Human Resources Research Organization, June 1970.

Psarakis, E.S., Underwater Terrain Navigation and Reconaissance Simulator, NAVTRAEQUIPCEN IH-198, Orlando, Florida: Naval Training Equipment Center, September 1971.

"The Rapid Spread of Training by Simulator," Business Week, May 24, 1976, pp. 62C, D, and F.

Reid, G.B. "Training Transfer of a Formation Flight Trainer," Human Factors, Vol. 17(5), 1975, pp. 470-476.

Report of the Task Force on Training Technology, Chapter 8, Crew/Group/Unit Training, Washington, D.C.: Office of the Director of Defense Research and Engineering, May 31, 1975.

Rigney, J.W. and Blaiwes, A.S. A Guide for the Application of Performance Structure-Oriented CAI in Military Jobs, NAVTRAEQUIPCEN IH-240, Orlando, Florida: Naval Training Equipment Center, 1974.

Rigney, J.W. and Munro, A. On Cognitive Strategies for Processing Text, Technical Report No. 80, University of Southern California, 1977.

Robins, J.E., Finley, D.L., and Ryan, T.G. Training Effectiveness Evaluation of Naval Training Devices: An Evaluation of the 2F69B ASW Weapon System Trainer, NAVTRAEQUIPCEN 70-C-0258-2, Orlando, Florida: Naval Training Equipment Center, December 1972.

Rockdale, Committee of Inquiry into British Shipping, HMSO, 1972.

Rocklyn, E.G. et al. A Method for Increasing the Training Effectiveness of Marine Corps Tactical Exercises: A Pilot Study, NPRDC TR-75-34, San Diego, California: Navy Personnel Research and Development Center, May 1975.

Rockway, M.R. The Effects of Variation in Control - Display Ratio and Exponential Time Delay on Tracking Performance. Technical Report WADC-54-618, December 1954, Wright Air Development Center, WPAFB, Ohio.

Roscoe, S.N. Effective and Economical Simulation in the Design and Use of Aero Systems, ARL 758/AFOSR 753, University of Illinois at Urbana-Champaign: Aviation Research Laboratory, Institute of Aviation, April 1975.

Roscoe, S.N. "Incremental Transfer Effectiveness," Human Factors, 1971, 13, 561-567.

Rules and Regulations for Licensing and Certificating of Merchant Marine Personnel, CG-191, Department of Transportation, Coast Guard, November 1, 1976.

Rumelhart, D.E. and Norman, D.A. Accretion, Tuning and Restructuring Three Modes of Learning, Report 7602, San Diego, California: Center for Human Information Processing, University of California, August 1976.

Scanland, W. "Instructional Technology in Naval Training," Proceedings of the National Security Industrial Association Conference on the State-of-the-Art Application of Advanced Training Technology (Ed. G. Rosinger), pp. 7-10, April 1977.

Schafer, T.H. and Shumaker, C.A. Comparative Study of the Audio and Visual Recognition Differential for a Pulse Masked by Random Noises. U.S. Navy Electronics Lab. Rep. 372, 1953.

Schumacker, D.J., Madsen, S.A. and Nicastro, F.X. Aviation/Marine - A Study of Contract, paper presented to the 17th Annual Tanker Conference of the Central Committee on Transportation by Water of the Division of Transportation of the American Petroleum Institute. May 8-10, 1972.

Senate Bill #682, Senator Magnuson, "To Amend the Ports and Waterways Safety Act of 1972" (Tanker Safety Act 1977), February 10, 1977.

Senate Bill #715, Senator Case, "To Amend the Ports and Waterways Safety Act of 1972" (Tanker Safety Act 1977), February 10, 1977.

REFERENCES (CONT'D)

Shiphandling Training by Simulator, Marine Safety International, LaGuardia Airport, Flushing, New York.

Shipley, P. The Changing World of Ship's Pilot, paper to Joint I.E.A. and Ergonomics Society Conference on Ergonomics and Other Contibutions to Employee Motivation, Satisfaction and Quality of Working Life. Wexham Springs, September 21-24, 1977.

Shoen, W.R. "Simulation in Navy Training," Proceedings of the National Security Industrial Association Conference on State-of-the-Art Application of Advanced Training Technology, (Ed. G. Rosinger), pp. 37-40, April 1977.

Sidorsky, R.C. and Simoneau, G.R. An Experimental Evaluation of TACTRAIN: An Approach to Computer-Aided Tactical Decision-Making Training, NAVTRADEVCEN 1329-4, Orlando, Florida: Naval Training Device Center, June 1970.

Slovic, P. and MacPhillany, D."Dimensional Commensurability and Cue Utilization in Comparative Judgment," Oregon Research Institute Research Bulletin, Vol. 11(14), 1971.

Smith, J., Daniels P., Paramore, B. and Porricelli, J. Task Analysis Report Relative to Vessel Collisions, Rammings, and Grounding, Vol. I, II, and III, Operations Research Inc., Silver Springs, Maryland, December 1976.

Smode, A., Gruber, A., and Ely, J.H. Human Factors Technology in the Design of Simulators for Operator Training, U.S. Naval Training Device Center, Port Washington, N.Y., NAVTRADEVCEN 1103-1, 1963.

Smode, A. Human Factors Inputs to the Training Device Design Process. NAVTRADEVCEN 69-C-0298-1, Orlando, Florida: Naval Training Device Center, September 1971.

Smode, A."Learning and Performance in a Tracking Task Under Two Levels of Achievement Information Feedback." Journal of Experimental Psychology: 1958, 56, 297-304.

Smode, A. Training Device Design: Human Factors Requirements in the Technical Approach, NAVTRADEVCEN 71-C-0013-1, Orlando, Florida: Naval Training Device Center, August 1972.

Snow, R.E. Individual Differences, Instructional Theory and Instructional Design, Technical Report No. 4, Stanford University, 1977.

Snow, R.E. Research on Aptitudes: A Progress Report, Technical Report No. 1, Stanford University, 1976.

Snow, R.E. Theory and Method for Research on Aptitude Processes: A Prospectus, Technical Report No. 2, Stanford University, 1976.

Solartron Schlumberger. The Solartron Electronic Group Limited, Farnborough Hampshire, England.

SOT Diagnostics, SOTAP Training Material Development, Vol. II, North Stonington, Connecticut: Eclectech Associates, Inc., March 1978.

SOTAP Training Materials Development: Vol. I, North Stonington, Connecticut, Eclectech Associates, Inc., February 1978.

Southampton School of Navigation, Decca Ship Simulator, Decca Radar Limited, Lyon Road, Walton-on-Thames, Surrey, England.

Specimen Examinations for Merchant Marine Deck Officer, CG-101-1 and CG-101-2, Department of Transportation, Coast Guard, April 1, 1976.

Stevens, A.L. and Collins, A. The Goal Structure of a Socratic Tutor, Report No. 3518, Cambridge, Massachusetts: Bolt, Beranek and Newman, 1977.

Stoehr, L.A., Morgan, C.H., Beuffler, F.J. and Tuller, P.M. Spill Risk Analysis Program: Methodology Development and Demonstration. Prepared by Operations Research, Inc. for the U.S. Coast Guard, National Technical Information Service, Springfield, Virginia, Accession No. AD043054, April 1977.

Stoehr, L. and Paramore, B. Handbook for the Development of Qualifications for Personnel in New Technology Systems, CG-D-75-76, Washington, D.C.: U.S. Coast Guard Office of Research and Development, February 1976.

Study Report, Changing Shipboard Duties and Recommendations for Training of Modern Ships' Deck Officers by Link Division of Singer-General Precision, Inc., Operational Training Division, Silver Spring, Maryland, Report No. 8264-101, June 1969.

Swedish State Shipbuilding Experimental Tank, SSPA, Box 24001, S-40022, Goteborg, Sweden.

Swink, J.R."The Systems Approach to Synthetic Training,"In 8th NTEC/ Industry Conference Proceedings, Orlando, Florida: November 18-20, 1975.

Szczuka, A.E. et al. Concept Feasibility Study for Training Equipment to Improve Coal Productivity, PB 254 863, St. Charles, Missouri: McDonnell Douglas Electronics Company, April 2, 1976

Talmadge, G.K. and Shearer, J.W. Study of Training Equipment and Individual Differences, Orlando, Florida: Naval Training Device Center, March 1967, Technical Report NAVTRADEVCEN 66-C-0043-1.

Talmadge, G.K., Shearer, J.W. and Greenberg, A.M. Study of Training Equipment and Individual Differences: The Effects of Subject Matter Variables. (NAVTRADEVCEN 67-C-011401. Contract N61339-67-C-0114) American Institute for Research in the Behavioral Sciences. May 1968.

Tanker Safety Pollution Prevention Conference, February 1978.

The Texas Star, Number 3, New York, 1977.

Thorndike, E.L. The Psychology of Learning (Educational Psychology. Vol. II, 1913), Theories of Learning, Hilgard and Bower: Appleton-Century Crofts, New York: 1966.

Toomepuu, J. Army Flight Simulator Programs From the User's Viewpoint, Fort Eustis, Virginia: U.S. Army Training and Doctrine Command, May 1976.

Townsend, J.M. Computer-Supported Operator Training for Ships Inertial Navigation Systems, NAVTRAEQUIPCEN IH-240, Orlando, Florida: Naval Training Equipment Center, 1974.

Umlauf, J.L., McIntosh, W.B., Jenkins, W. and Francis, B. Technical Report for Study of Human Performance Related to Bridge Personnel on Maritime Vessels, Vol. I and II, Oceanographic Institute of Washington, Seattle, Washington, December 1975.

United Airlines, Personel Communications, Captain G.V. McCulloch, Training Manager and Captain J.E. Carroll, Vice President of Flight Training, May 1977.

U.S. Army Training and Doctrine Command Study Plan WST and Training Effectiveness (CTEA) of the CH-47 Flight Simulator, Fort Rucker, Alabama: U.S. Army Aviation Center, December 3, 1976.

Valveide, H. "A Review of Flight Simulator Transfer of Training Studies," Human Factors, 15(6), 510-523, 1973.

Valverde, H. Flight Simulators - A Review of the Research and Development, AMRL-TR-68-97, Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratory, July 1968.

VanCott and Kinkade, Human Engineering Guide to Equipment Design, American Institute for Research, 1972.

VanManen, J.D. and Hooft, J.P. A Three-Dimensional Simulator for Maneuvering of Surface Ships, International Shipbuilding Progress, October 1970.

Vernam, C.G. and Kennedy, P."Implementation of ISD-Restructuring of the Radioman Curriculum ," Proceedings of the National Security Industrial Association Conference on State-of-the-Art Application of Advanced Training Technology, (Ed. G. Rosinger), pp. 11-16, April 1977.

Wagner, H. et al. Team Training and Evaluation Strategies: A State-of-the-Art Review, HumRRO Report SR-E-D-76-11, Alexandria, Virginia: Human Resources Research Organization, June 1976.

Warrick, M.J. Effect of Transmission-type Control Lags on Tracking Accuracy, USAF Air Mat. Com., Technical Report No. 5916, 1949.

Watson, P.R. and Stewart, A."Shiphandling Simulation and Marine Training," presented to the Universities' Transport Studies Group, January 7-9, 1975

Webb, N.M. Learning in Individual and Small Group Settings, Technical Report No. 7, Stanford University, 1977.

Weisz, A.Z. and McElroy, L.S. Response and Feedback Techniques for Automated Training of Visual Identification Skills (NAVTRADEVCEN Tech. Rep. 789-3) Orlando, Florida: Naval Training Device Center, July 1964.

Wescount, K.T. et al. Knowledge-based CAI. CINS for Individualzed Curriculum Sequencing, Technical Report 290, Stanford University, 1977.

Williges, B.H., Roscoe, S.N., and Williges, R.C. Synthetic Flight Training Revisited, ARL 7221/AFOSR 72-10, University of Illinois: Aviation Research Laboratory, Institute of Aviation, August 1972.

Woodworth, R.S. and Schlosberg, H. Experimental Psychology, Holt, Rinehart and Winston, 1963.

REFERENCES - (CONT'D)

Woodworth, R.S. and Schlosberg, H. Experimental Psychology, New York: Henry Holt and Company, 1954.

Zade, G. "Cost and Benefit of Nautical Simulators, A User's Point of View." The College of Nautical Studies, Southampton, UK:MARSIM '78, September 5-8, 1978.

Zade, G. Hochschule Fur Nautek Bremen, Cost and Benefit of Nautical Simulators - A Users Point of View - Marsim, 1978.